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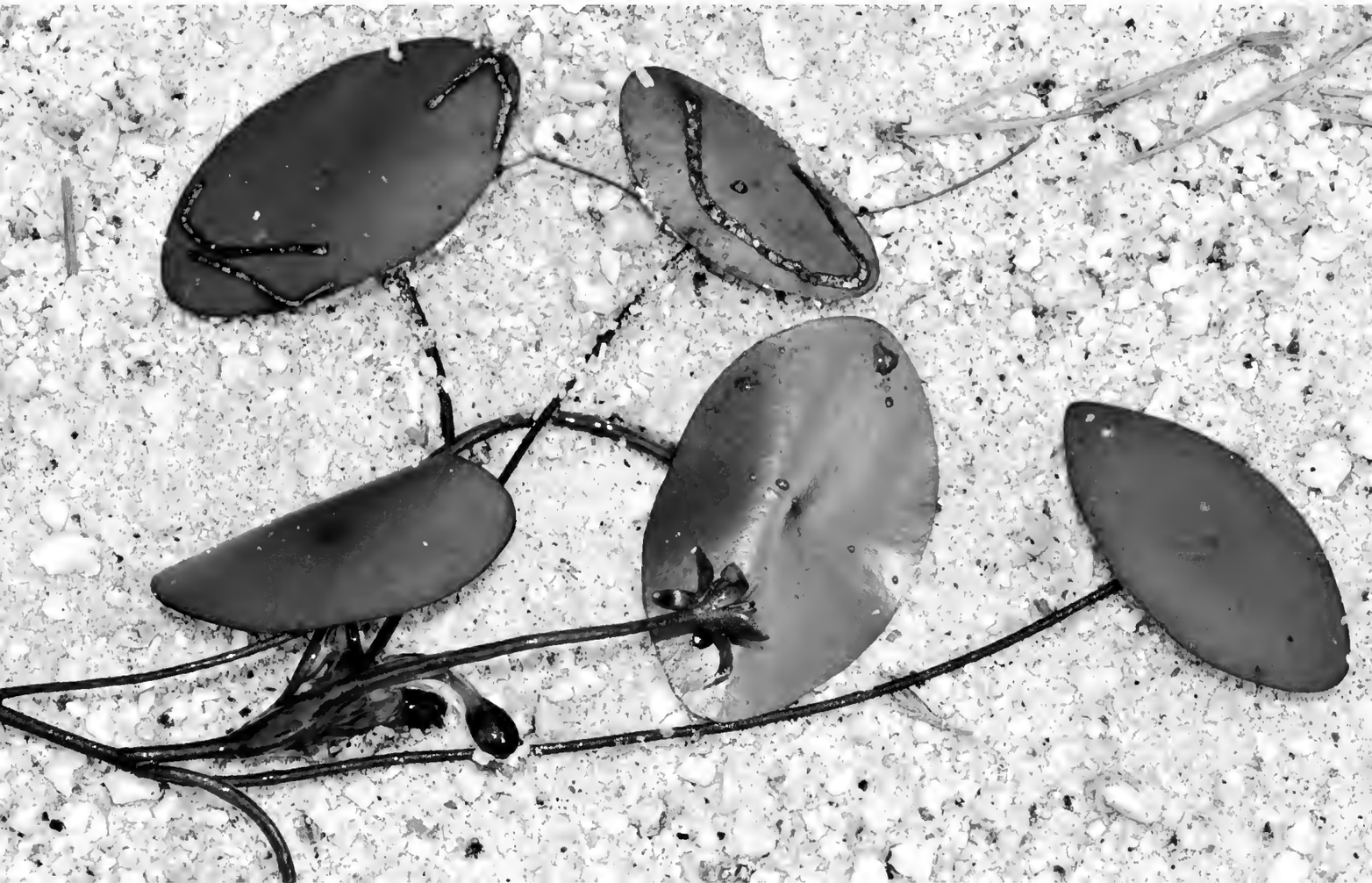
THE GREAT LAKES BOTANIST

A Journal of North American Botany



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THE GREAT LAKES BOTANIST publishes papers on all aspects of the natural history of plants of North America north of Mexico, including systematics, floristics, ecology, conservation, botanical history, economic botany and ethnobotany, restoration, and other areas of organismal botany. Plant groups include vascular plants, bryophytes, fungi, and algae. The journal maintains the Great Lakes region as one area of special focus. The Great Lakes region is defined as the entirety of the states and provinces bordering any of the Great Lakes, that is, Michigan, Wisconsin, Minnesota, Illinois, Indiana, Ohio, Ontario, Pennsylvania, and New York.

On all editorial matters, please contact the Editor, Michael Huft, 232 Akela Dr., Valparaiso, IN 46385. Phone: (847) 682-5240; email: mhuft@att.net. All articles dealing with botany in North America may be sent to the Editor at the above address. In preparing manuscripts, authors are requested to follow the "Instructions to Authors" on the inside back cover and, more fully, at http://quod.lib.umich.edu/m/mbot/submit.

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Membership is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on plant life; sponsorship of legislation to promote the preservation of Michigan's native flora; establishment of suitable sanctuaries and natural areas, and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

Dues are modest, but vary slightly among the chapters. To become a chapter member please contact the chapter presidents listed below. Annual dues include a subscription to *The Michigan Botanist*. Address changes for Chapter Members should go to the Chapter President.

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EDITOR'S NOTE

This is the first issue of this journal, formerly known as *The Michigan Botanist*, to be published under the name *The Great Lakes Botanist*. The new name reflects the fact that, since its inception, *The Michigan Botanist* has published papers on the botany of the Great Lakes region, including numerous articles pertaining to the plants of Wisconsin, Minnesota, Illinois, Indiana, Ohio, and Ontario. The new legend on the cover, "A Journal of North American Botany," which replaces the previous legend, "A Journal of Great Lakes Botany," indicates that, along with the new name, the coverage of this journal is expanded to all of North America north of Mexico. Nevertheless, the Great Lakes area, now expanded to include also the states of Pennsylvania and New York, will continue to be one area of special focus.

Accordingly, we invite submissions of articles pertaining to plant life of North America generally. *The Great Lakes Botanist* is a peer-reviewed, open-access, journal that publishes articles on all aspects of the natural history of plants of North America north of Mexico, including systematics, floristics, ecology, conservation, botanical history, economic botany and ethnobotany, restoration, and other areas of organismal botany. Plant groups include vascular plants, bryophytes, fungi, and algae. Currently, there are no page charges.

APPOINTMENT OF NEW ASSISTANT EDITOR

I am pleased to announce the appointment of Daniel Kashian as Assistant Editor of *The Great Lakes Botanist*, who is tasked with developing ways of attracting and publishing content of interest to the broader non-professional membership of the Michigan Botanical Club. Since the majority of the financial support of the journal comes from dues paid by members of the Michigan Botanical Club, it is important that the journal include some content that is geared to the interests of this largely nonprofessional readership while still maintaining, and even enhancing, the professional quality of the journal. Dan is a professor of Biological Sciences at Wayne State University, whose specialty is forest ecology. He already has editorial experience with *The Great Lakes Botanist*, having done outstanding work coordinating the special issue commemorating Burt Barnes (Volume 54, Nos. 1–2).

IN THIS ISSUE

This first issue of *The Great Lakes Botanist* opens with a report by Sam Brinker of the first occurrence in the Great Lakes area of the arctic-alpine plant *Chamaenerion latifolium* (Onagraceae), a close relative of the widely-distributed fireweed (*C. angustifolium*). This report is from the western Lake Superior re-

gion in Ontario; the closest known occurences are 700 km to the north near the shore of Hudson Bay and in the Rocky Mountain region to the west.

This is followed by Julie Craves's collection of measurements of fruits of bird-dispersed plants in southeastern Michigan. In addition to her own measurements, however, the author adds much of value by providing these measurements in the context of measurements of the same plants by other authors from wide-ranging geographical regions as well as providing an invaluable resource in the form of an extensive bibliography.

Thomas Lammers, of the University of Wisconsin-Oshkosh, follows up his historical article on a little-known Michigan botanist in the last issue of this journal with another historical account, this time of the collections of Edwin James, who is best known as the botanist on the 1820 Long expedition to the Rocky Mountains, during his relatively short stay in the Prairie du Chien area of Wisconsin during the mid-1820s. The article includes biographical details of James's stay in Wisconsin, discusses his interest in Native American linguistics, and enumerates James's collections, including comments on each from James's unpublished diary and the modern botanical names of each.

Emily Mydlowski and Michael Rotter present a study of the effect of mucilage that covers the lower surface of leaves of watershield, *Brasenia schreberi*, on the level of herbivory by three aquatic insects. The results suggest that the amount of mucilage differentially deters herbivory, and the authors suggest additional laboratory studies that can be conducted.

The *Great Lakes Botanist* has published extensively on the plants of the islands in Lake Michigan throughout its history. In this issue, Daniel Wujek and Edwin Leuck II extend this history by bringing us up to date with the flora of the largest of these islands, Beaver Island, with an annotated list of 50 additional plants to the island as well as more general comments on the flora of Beaver Island.

Ludington State Park lies on the shore of Lake Michigan near the tension zone between the northern hardwood forest to the south and the boreal forest to the north. For that reason, David Dister's flora of the park is a particularly valuable contribution. In addition to providing the results of his own explorations in the park over a four-year period, the author includes historical collections in order to present a complete listing of the vascular flora, provides a discussion of the natural communities that occur within the park, and compares the characteristics of the park flora with that of a neighboring wilderness area with a somewhat different history.

This issue concludes with reviews of Joe Johnson's long-awaited flora, *The Vascular Plants of the Bruce Peninsula, Ontario*, which for the first time provides a comprehensive account of this rich and interesting flora, and of the revised edition of Claude Barr's *Jewels of the Plains*, a one-of-a-kind tour and appreciation of the fascinating plants of the Great Plains.

——Michael Huft

DISCOVERY OF *CHAMAENERION LATIFOLIUM* (L.) HOLUB (ONAGRACEAE) IN THE GREAT LAKES REGION

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ABSTRACT

The first report of *Chamaenerion latifolium* (L.) Holub in the Great Lakes region is described from Kama Hills, near Nipigon, Ontario. This showy, long-lived herbaceous perennial is a circumpolar arctic and alpine plant of well-irrigated, open calcareous floodplains, river bars, seepage slopes, and scree slopes in alpine zones. Its presence in the region is remarkable, being disjunct from the next nearest populations over 700 km to the north. It adds to the list of disjunct arctic-alpine plants restricted to isolated pockets of disturbance-maintained, open rocky sites that have remained relatively unchanged since the retreat of the Wisconsinan glacier roughly 11,000 years ago.

KEYWORDS: *Chamaenerion latifolium*, disjunct arctic-alpine, western Lake Superior region, Thunder Bay District.

INTRODUCTION

Chamaenerion latifolium (L.) Holub (Onagraceae) is reported here as new for the Great Lakes basin and the Thunder Bay District in Ontario. Additionally, this record appears to be the most southerly occurrence of this species east of the Rocky Mountains, as illustrated in Figure 1. An early literature report exists from the Black Hills region of South Dakota in McIntosh (1931), though no substantiating specimens have been found, nor do recent floras for the region include this taxon (e.g., Dorn et al 1977, VanBruggen 1985, Marriott 1986) other than referencing the historical report and lack of a supporting specimen. The small population of roughly 100 mostly non-flowering plants is disjunct from the nearest population to the north by roughly 700 km. Its occurrence in the Great Lakes basin is remarkable and mirrors the distribution of several other disjunct arctic-alpine vascular plants in the region, e.g., *Pyrola grandiflora* Radius, *Saxifraga oppositifolia* L., *Carex glacialis* Mackenzie, *Dryas integrifolia* Vahl, and *Cerastium alpinum* L., among others (for more complete discussions and lists see Butters and Abbe 1953; Soper and Maycock 1963; Given and Soper 1981; Bakowsky 1998).

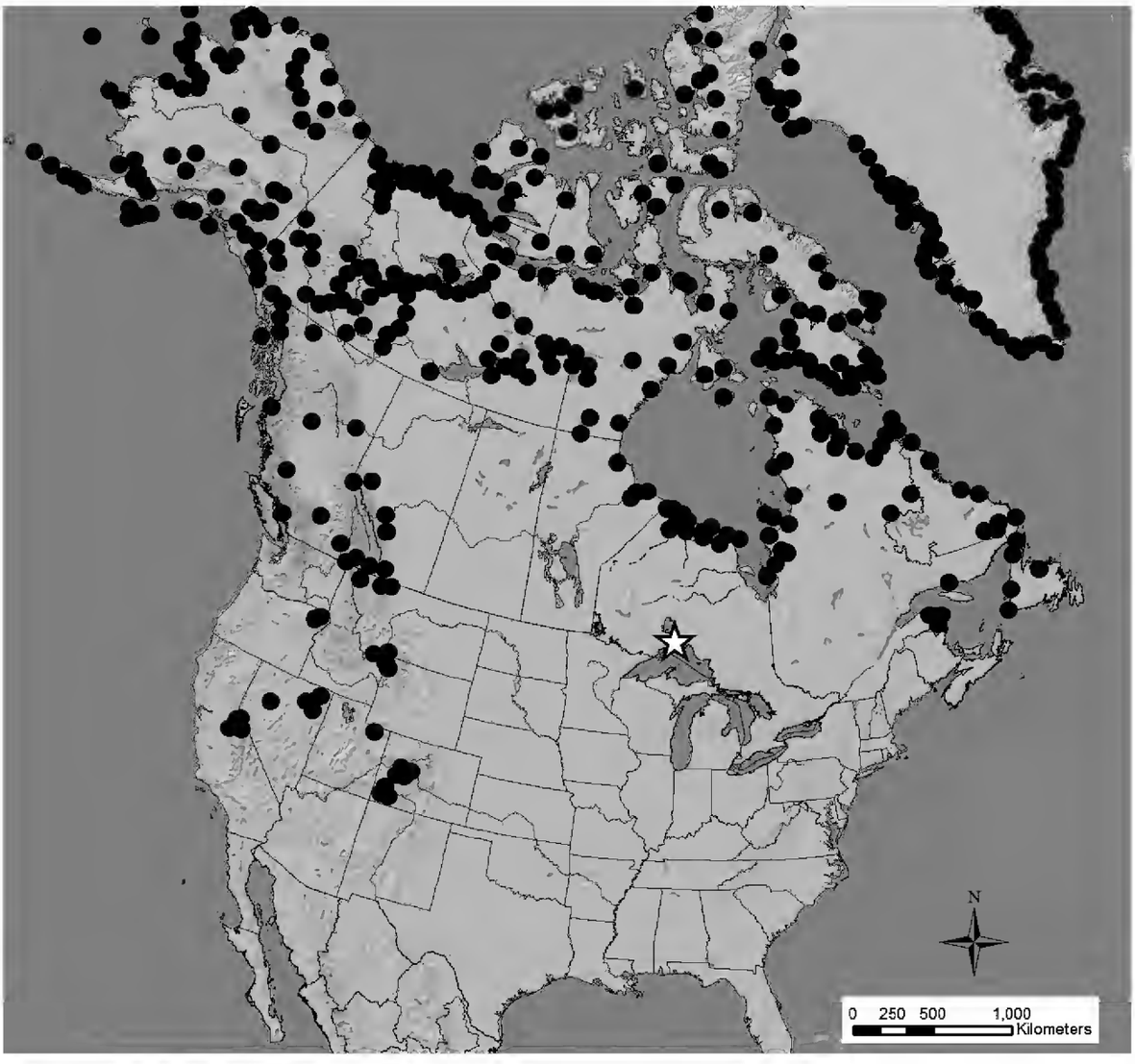

FIGURE 1. North American range map of *Chamaenerion latifolium* (adopted from Small 1968; Porsild and Cody 1980; and Aiken et al. 2007). The Kama Hills site in the Lake Superior basin is represented by a white star.

DISTRIBUTION AND ECOLOGY

Chamaenerion latifolium (Figure 2), which is known under the vernacular names Arctic Fireweed, Alpine Fireweed, Dwarf Fireweed, Broad-leaved Fireweed, River Beauty, and Épilobe à feuilles larges, is a long-lived perennial herb of arctic and alpine habitat found throughout the Northern Hemisphere, including North America, Greenland, Iceland and northern Russia, but is absent from most of northern Europe. It is highly disjunct in southern Asia, occurring in the Himalayas from Afghanistan to western China (Small 1968). In North America, it is found in Alaska, Yukon, the Northwest Territories, Nunavut, Labrador, and Newfoundland, portions of northern Manitoba, Ontario, and Quebec, as well as sporadically throughout the Canadian Arctic Island Archipelago (Figure 1) (Porsild and Cody 1980; Aiken et al. 2007). In the West, its range extends south along the Rocky Mountains culminating a trend in the western Cordillera to increas-

FIGURE 2. *Chamaenerion latifolium*, growing on wet, vertical rock at Kama Hills, Thunder Bay District, Ontario. Photo by Samuel Brinker.

ingly isolated and elevated sites, the southernmost of which occur in Colorado at 12,500 ft (Small 1968).

A pioneer species, *Chamaenerion latifolium* is an excellent colonizer of successional habitat and can often be found in abundance, forming monospecific stands on calcareous substrates that are usually well-irrigated, such as gravel bars, alluvial floodplains, newly exposed glacial tills, seepage slopes, edges of snow patches, and even disturbed roadsides. Despite being a long-lived perennial and a highly efficient colonizer, *C. latifolium* is a poor competitor. According to Doak (1991), it shows its greatest growth and reproduction when colonizing sparsely vegetated sites, quickly decreasing in abundance and vigor as other species invade.

Plants arise from pseudorhizomes, a slight thickening of the underground stem which bear annual shoots that originate as branches at or below ground level of the previous years' growth (Doak 1991). Each pseudorhizome can persist for several years, but eventually dies off creating autonomous plants. *Chamaenerion latifolium* is an excellent disperser, distributed by comose, windblown seeds.

FIGURE 3. Medicolous cliff habitat at Kama Hills, Ontario. The plants were restricted to the central portion of the upper vertical tier of the rock face with direct sunlight exposure. Photo by Samuel Brinker.

DISCUSSION

The Lake Superior region has long been known to harbour assemblages of arctic and alpine plant species adapted to its cold, exposed rocky shores dotted with sparse, often stunted conifer trees and low ericaceous shrubs found more abundantly in the adjacent uplands. The region's unique landscape and its geologic and edaphic diversity are thought to have maintained small areas of exposed, open habitat following the retreat of the Wisconsinan ice sheets that formerly covered the region until roughly 11,000 years ago (Saarnisto 1974). As the regional climate ameliorated and the ice sheets receded, the cold-adapted vegetation that colonized the recently exposed land was largely replaced by boreal forest. The continued presence of this unique assemblage of plants is therefore assumed to be relictual, persisting in small isolated pockets of open habitat originating from late-glacial and post-glacial colonization via step-wise or long-distance dispersal. Well-known sites harbouring arctic-alpine floral assemblages tend to be coastal (e.g., Old Woman Bay) and are often on remote islands (e.g., Slate Islands, Isle Royale), in isolated inland canyons (e.g., Ouimet Canyon, Ottertooth Canyon), or on exposed diabase cliff and talus slopes which often harbour a more characteristically Western Cordilleran floral element (e.g., North Fowl Lake).

The occurrence of *C. latifolium* on a water-fed cliff face is noteworthy in that

TABLE 1. Disjunct arctic-alpine plants "partially tracked" in Ontario's Great Lakes basin. These plants are locally common in extreme northern Ontario near Hudson Bay and James Bay but occur very rarely around the shores of the Great Lakes, separated by hundreds of kilometers from their normal range. These populations have different natural and anthropogenic threats from those of the northern populations and are therefore tracked only in this region of the province.

Scientific Name	Common Name
Anemone parviflora Michaux	Small-flowered Anemone
Astragalus alpinus L.	Alpine Milk-vetch
Carex glacialis Mackenzie	Glacier Sedge
Carex saxatilis L.	Russet Sedge
Carex scirpoidea Michaux ssp. *scirpoidea*	Single-spike Sedge
Castilleja septentrionalis Lindley	Northeastern Paintbrush
Cerastium alpinum L.	Alpine Chickweed
Chamaenerion latifolium (L.) Holub	River Beauty
Draba aurea Vahl ex Hornemann	Golden Draba
Dryas integrifolia Vahl	Entire-leaved Mountain Avens
Poa alpina L.	Alpine Bluegrass
Poa pratensis L. ssp. *alpigena* (Lindman) Hiitonen	Alpigene Bluegrass
Pyrola grandiflora Radius	Arctic Pyrola
Saxifraga tricuspidata Rottbøll	Three-toothed Saxifrage
Solidago multiradiata Aiton	Multi-rayed Goldenrod
Tanacetum bipinnatum (L.) Schultz-Bipontinus	Dwarf Tansy
Taraxacum ceratophorum (Ledebour) de Candolle	Horned Dandelion
Tofieldia pusilla (Michaux) Persoon	Small False Asphodel

this habitat is distinct from the more typical arctic-alpine habitat types mentioned above that have received more extensive botanical attention. The unusual wet vertical rock surface is much scarcer than the more typical dry cliffs in the region and closely mimics ice-scoured river banks and seepage slopes typical of *C. latifolium* habitat in arctic and alpine regions and limits competition from woody invasion.

The vegetation at the Kama Hills site illustrated in Figure 3 is sparse, dominated by bryophytes and low herbaceous plants and with few woody species as a result of the lack of soil development. Other moisture-loving calciphiles present included *Primula mistassinica* Michx. and *Dasiphora fruticosa* (L.) Rydb. The constant water supply here and the northwest aspect create a distinctly humid and colder than normal microclimate.

Although *Chamaenerion latifolium* is relatively common in northern Ontario, this isolated population disjunct from its main range may be especially sensitive to climate change. Such peripheral populations of arctic-alpine plants have been highlighted as particularly vulnerable to warming climates (Lesica and McCune 2004; Klanderud 2008; Gibson et al. 2009), and local extinctions of peripheral populations from their core may mean losses of genetic distinctiveness (Hampe and Petit 2005; Hamilton and Eckert 2007). This population occurs in the Kama Hills Provincial Conservation Reserve and thereby is protected from direct anthropogenic threats such as logging, mining, or development. *Chamaenerion latifolium* joins a list of disjunct arctic-alpine vascular plants in the Lake Superior

region that, despite being more common further north in Ontario, are being monitored (partially tracked) in the Great Lakes basin because of the unique set of threats that they face, namely climate change, shoreline development, and small population size. It is considered globally Secure (G5) (NatureServe 2015, as *Chamerion latifolium*), nationally Secure in Canada (CESCC 2011), and Apparently Secure (S4) in Ontario (Oldham and Brinker 2009). Table 1 lists the current disjunct arctic-alpine plants that are rare in the Great Lakes basin, but which are generally common and widespread in Ontario's Hudson Bay lowland.

DIAGNOSTIC CHARACTERS

Chamaenerion latifolium can be distinguished from the other showy species of *Chamaenerion* in the region, *C. angustifolium* (L.) Holub, by its low, decumbent to ascending, often branched stem (up to 40 cm) and compact, few-flowered raceme. *Chamaenerion angustifolium* is taller (up to 1 m), with an erect, usually single stem, and an elongated, many-flowered raceme. Also, the base of the style is glabrous in *C. latifolium*, whereas it is pubescent in *C. angustifolium*. *Chamaenerion latifolium* is restricted to wet, calcareous cliff habitat in the Lake Superior region, whereas *C. angustifolium* is widespread in meadows, clearings, open forests, and recently burned or otherwise disturbed areas.

SPECIMEN CITATION

ONTARIO, THUNDER BAY DISTRICT: Kama Hills Conservation Reserve, 19 km east of Nipigon, on medicolous, sheltered rock face with *Phegopteris connectilis*, *Primula mistassinica*, *Calamagrostis canadensis*, *Rubus pubescens*, and *Dasiphora fruticosa*. Roughly 100 mostly non-flowering stems, August 21, 2015, *Brinker 4647* (DAO, MICH).

ACKNOWLEDGMENTS

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MORPHOLOGICAL TRAITS OF COMMON AUTUMN-RIPENING BIRD-DISPERSED FRUITS IN SOUTHEASTERN MICHIGAN

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ABSTRACT

Fruit size, seed load, and seed size are considered important metrics that influence fruit choice and subsequent seed dispersal by birds. I describe these traits for 37 plant taxa in southeastern Michigan, based on measurements of over 5,800 fruits and 8,000 seeds. I also provide literature reports of nearly 200 measurements for the same taxa. These data can be used in biogeographical studies and can also aid in conservation and restoration efforts by describing the traits that are preferred by birds, which in turn influence seed dispersal through landscapes.

INTRODUCTION

Seed dispersal mechanisms drive plant population dynamics. In temperate zones, up to half of all plant species may have fleshy fruits (Willson 1986; Willson et al. 1989; Uriarte et al. 2011), and birds are their primary dispersers (Snow and Snow 1988; Greenberg and Walter 2010). Thus, birds are major agents in the movement of seeds through landscapes and act as important architects of plant demographics (Jordano 2000; Uriarte et al. 2011). Recognition of the traits that increase the probability of fruit selection and the quality of the resulting seed dispersal adds to our understanding of the spread and distribution of bird-dispersed plants (Gosper et al. 2005; Buckley et al. 2006; Westcott and Fletcher 2011; McConkey et al. 2012).

Fruit choice in birds is a complex, often hierarchial, process (McPherson 1987; Sallabanks 1993; Foster 2008). Potential factors that may influence bird visits to fruiting plants are plant abundance and neighborhood composition (Sargent 1990; Carlo 2005), crop size (Denslow 1987; Takahashi and Kamitani 2004; Blendinger and Villegas 2011), plant structure and fruit accessibility (Moermond and Denslow 1983; Levey et al. 1984), and display (Willson and Melampy 1983; Whelan and Willson 1994). Individual fruit selection may be guided by physical fruit traits including color, chemistry, size, seed load, and seed size (Levey 1987; Nakanishi 1996; Gosper et al. 2005; Jordano 2000).

Fruit size is a critical trait, as birds seek to maximize handling efficiency and are limited by the size of their gapes (Herrera 1984; Wheelwright 1985; Levey 1987; Jordano 2000). Seed size often determines the distance and spatial patterns of dispersal (Hernández 2009; Uriarte et al. 2011). Large seeds (relative to

bird size) are usually dropped or regurgitated close to the parent plant, whereas small seeds are typically swallowed and later defecated, often some distance away; a longer gut retention time in the latter case may also enhance germination (Johnson et al. 1985; Levey 1987; Hoppes 1988; Fukui 2003). The number of seeds per fruit also plays a role in dispersal distance, as gut displacement may influence the rate of seed passage (Stapanian 1982; Levey 1987).

A number of studies have found that fruit and seed morphology may vary geographically (e.g., Cech and Kitzmiller 1968; Hampe and Bairlein 2000; García et al. 2001; Hampe 2003). Despite this fact and the relevance of these traits to fruit choice by birds and subsequent seed dispersal, few compilations of fruit morphology that provide specific location-based data exist. As part of a larger study on the use of urban natural areas by birds and of fruits in bird diets (Craves 2009; Craves 2015), I compiled data on the morphological traits of autumn-ripening fleshy fruits of plants in Wayne and Washtenaw counties in southeastern Michigan. I also compiled literature reports of measurements for the same species from other localities.

MATERIALS AND METHODS

I define "fruits" here in a functional sense as seed-containing structures with nutritious, fleshy pulp consumed by birds. Depending on the species, fruits may be berries, drupes, pomes, or fleshy cones. Likewise, "seeds" refers to the dispersal unit of the plant, whether it is technically a seed, a stone, an achene, or a similar structure (Stapanian 1982; Willson 1986; Snow and Snow 1988).

This study includes most of the common bird-dispersed, fleshy-fruited plants found in southeastern Michigan, comprising native plants as well as non-native plants that occur outside of cultivation (Voss and Reznicek 2012). Plants were considered "bird-dispersed" if birds were observed feeding on their fruits or if their seeds were found in fecal samples collected from banded birds or from seed traps ($n>5,900$ samples and >38,000 seeds from 22 bird species) as part of a larger study on the role of fruit in bird diets (Craves 2009; Craves 2015).

From 2013 through 2015, fruits were collected for measurements primarily at or near the campus of the University of Michigan-Dearborn, Dearborn, Wayne County, and in section 5 of Lodi Township, Washtenaw County. At least ten ripe fruits of each taxon were collected approximately once a week during the period coinciding with fall bird migration (early to mid-August through early November). In North America, many migratory bird species that are primarily insectivorous feed heavily on fruit in fall and winter, and large fruit crops become available to birds at this time (Thompson and Willson 1979; Baird 1980; Willson 1986; Parrish 1997; Jordano 2000). Fruits were collected from the time of first ripening until depletion. If fruits remained past early November, they were collected until they were depleted, or until the only remaining fruits were dry, shriveled, or malformed; such fruits were not measured. During each sampling session, I chose fruits from multiple plants growing in various conditions, if possible, to reduce the bias that might arise from the variability in fruit or seed size in different years (García et al. 2001; Parciak 2002) or within a single season (Gorchov 1985; Hernández 2009; but see Eriksson and Ehrlén 1991) or that are caused by differences in maternal environment (Baskin and Baskin 1998; Silander and Klepeis 1999; Schulz and Wright 2015).

Measurements were made on fresh fruits within several hours of collection. Immediately after measuring a fruit, I stripped the pulp from the seeds and counted and measured them. I measured the greatest dimension of each fruit or seed with digital Vernier calipers to the nearest 0.01 mm. Most fruit were globose or nearly so, and thus the greatest dimension was the diameter or width, usually perpendicular to the stalk of the fruit. For elliptical or elongated fruits or seed, the greatest dimension was the length.

Measurements for the same taxa that were collected in southeastern Michigan were compiled from the literature whenever the source indicated that they were obtained in a particular geographic region and provided the mean of the measurements. I searched multiple online databases, websites,

and major scientific publishers. I searched for each species by name and also used combinations of plant generic names with terms such as "fruit," "seed," "morphology," or "traits." Nevertheless, my compilation is not exhaustive.

RESULTS

I measured 5,810 fruits and 8,195 seeds of 37 taxa (Table 1). Fruits and seeds of all these taxa were found in bird fecal samples except for *Lindera benzoin, Menispermum canadense,* and *Solanum ptychanthum* (see Table 1 for common names and taxonomy), although birds were occasionally observed eating fruits of these species. *Celastrus* seeds were found in fecal samples only from Wayne County, where *C. scandens* is rare, but where *C. orbiculatus* is abundant. Only five species were found in more than ten percent of the fecal samples (and therefore considered a major dietary component, after Jordano 1988): *Lonicera maackii, Rhamnus cathartica, Phytolacca americana*, *Vitis riparia,* and a cultivated, small-fruited, non-native *Malus* (crabapple) species. I did not include measurements from fruit or seeds of the latter, since I was unable to determine its parentage, and no individuals of the small-fruited *Malus* were located outside cultivation.

I located 199 measurements for 33 species in the literature (Table 2). My *Ligustrum* measurements included fruit from some plants with ambiguous characteristics that may have been hybrids, so I included measurements for *L. obtusifolium* and *L. vulgare* from the literature. I found none of the target measurements for *Viburnum lentago, Berberis thunbergii, Pyrus calleryana, Rosa setigera, Solanum ptychanthum,* or *Parthenocissus inserta.* For the latter, I substituted measurements found for its close relative *P. quinquefolia*, since the two species are easily confused and both are often referred to as "Virginia Creeper" (Pringle 2010). Reports of fruit size of six of the species, seed count of three species, and seed size for 21 species were not found.

DISCUSSION

I describe three important morphological traits—fruit size, seed count, and seed size—for 37 taxa of autumn-ripening, fleshy-fruited, bird-dispersed plants from southeastern Michigan. Measurements for nearly a third of these species are not readily available in the literature. This is surprising considering that a number of them (e.g., *Berberis thunbergii*, *Frangula alnus*, *Rhamnus cathartica*, *Pyrus calleryana*, *Rosa mulitflora*, and *Ligustrum* spp.) are important non-native, invasive species. The success of many fleshy-fruited invasive species is in part due to fruit traits that have facilitated their dispersal by birds (Buckley et al. 2006; Gosper and Vivian-Smith 2010).

The average size of the fruits I measured was just under 8 mm. Average seed count was approximately five, and the average greatest dimension of seeds just under 5 mm. These measurements correspond well with those in other compilations of bird-dispersed fleshy fruits (Wheelwright 1985; Jordano 1995; Nakan-

TABLE 1. Morphometrics (mean ± SE) of common bird-dispersed, fleshy fruits collected in southeastern Michigan. Fruit and seed sizes are the greatest dimension, usually diameter or width for spherical, and length for non-spherical, fruits and seeds. Species not native to North America are indicated by boldface type. Nomenclature and common names follow Voss and Reznicek (2012), with additional common names from USDA, NRCS (2016). Commonly encountered synonyms are indicated in square brackets.

Taxon	Fruit size (mm)	Seed count per fruit	Seed size (mm)
CUPRESSACEAE			
Juniperus virginiana L., Red Cedar, Eastern Redcedar	5.96±0.09 (n=185)	1.77±0.06 (n=185)	3.49±0.06 (n=190)
ADOXACEAE			
Viburnum lentago L., Nannyberry	11.2±0.07 (n=135)	1.00±0.00 (n=135)	9.74±0.06 (n=135)
***Viburnum opulus* L.**, European Highbush-Cranberry, Guelder-Rose, European Cranberrybush	10.29±0.11 (n=105)	1.00±0.00 (n=105)	8.27±0.10 (n=105)
ANACARDIACEAE			
Rhus glabra L., Smooth Sumac	4.23±0.06 (n=75)	1.00±0.00 (n=75)	3.17±0.05 (n=75)
Rhus typhina L., Staghorn Sumac	5.18±0.06 (n=160)	1.00±0.00 (n=160)	3.61±0.04 (n=140)
Rhus combination[1]	4.88±0.05 (n=235)	1.00±0.00 (n=235)	3.46±0.03 (n=215)
Toxicodendron radicans (L.) Kuntze, Poison-Ivy, Eastern Poison Ivy	4.37±0.04 (n=110)	1.00±0.00 (n=110)	4.04±0.04 (n=225)
AQUIFOLIACEAE			
Ilex verticillata (L.) A. Gray, Winterberry, Michigan Holly, Black-Alder, Common Winterberry	7.62±0.06 (n=135)	5.13±0.12 (n=135)	4.06±0.04 (n=185)
BERBERIDACEAE			
***Berberis thunbergii* DC.**, Japanese Barberry	9.92±0.06 (n=150)	1.49±0.04 (n=150)	6.59±0.04 (n=155)
CANNABACEAE			
Celtis occidentalis L., Hackberry, Common Hackberry	7.31±0.03 (n=115)	1.00±0.00 (n=115)	6.19±0.05 (n=115)
CAPRIFOLIACEAE			
***Lonicera japonica* Thunb.**, Japanese Honeysuckle	6.20±0.08 (n=135)	7.70±0.34 (n=135)	3.15±0.03 (n=155)
***Lonicera maackii* (Rupr.) Herder**,[2] Amur Honeysuckle	6.51±0.07 (n=465)	3.98±0.10 (n=465)	3.90±0.02 (n=820)

(*Continued*)

TABLE 1. Continued.

Taxon	Fruit size (mm)	Seed count per fruit	Seed size (mm)
CELASTRACEAE			
***Celastrus orbiculatus* Thunb.**, Oriental Bittersweet	6.62±0.06 (n=155)	4.41±0.11 (n=155)	3.98±0.02 (n=205)
Celastrus scandens L., Climbing Bittersweet, American Bittersweet	7.87±0.10 (n=105)	3.19±0.14 (n=105)	5.05±0.03 (n=220)
***Euonymus alata* (Thunb.) Siebold**, Winged Euonymus, Burningbush	6.36±0.06 (n=130)	1.03±0.01 (n=130)	4.65±0.03 (n=130)
CORNACEAE			
Cornus amomum Mill., Silky Dogwood, Pale Dogwood	7.43±0.06 (n=150)	1.00±0.00 (n=150)	5.35±0.04 (n=150)
Cornus drummondii C. A. Mey., Rough-leaved Dogwood, Roughleaf Dogwood	6.04±0.05 (n=150)	1.00±0.00 (n=150)	3.96±0.04 (n=150)
Cornus florida L., Flowering Dogwood	10.63±0.11 (n=75)	1.00±0.00 (n=75)	8.32±0.09 (n=75)
Cornus foemina racemosa (Lam.) J. S. Wilson., [*Cornus racemosa* Lam.] Gray Dogwood	6.09±0.05 (n=175)	1.00±0.00 (n=175)	4.75±0.05 (n=175)
Cornus sericea L., [*Cornus stolonifera* Michx.] Red-osier, Redosier Dogwood	7.05±0.06 (n=200)	1.00±0.00 (n=200)	4.83±0.04 (n=200)
ELAEAGNACEAE			
***Elaeagnus umbellata* Thunb.**, Autumn Olive, Autumn-Olive	7.55±0.07 (n=155)	1.00±0.00 (n=155)	6.79±0.07 (n=155)
LAURACEAE			
Lindera benzoin (L.) Blume, Spicebush, Northern Spicebush	9.12±0.14 (n=50)	1.00±0.00 (n=50)	7.02±0.11 (n=50)
MENISPERMACEAE			
Menispermum canadense L., Moonseed, Common Moonseed	9.30±0.07 (n=140)	1.00±0.00 (n=140)	7.94±0.04 (n=140)
OLEACEAE			
***Ligustrum* spp.**,[3] Privet	6.42±0.04 (n=220)	1.00±0.01 (n=220)	5.89±0.03 (n=220)
PHYTOLACCACEAE			
Phytolacca americana L., Pokeweed, American Pokeweed	8.90±0.05 (n=225)	9.29±0.09 (n=185)	3.07±0.01 (n=500)
RHAMNACEAE			
***Frangula alnus* Mill.**, Glossy Buckthorn	7.61±0.06 (n=200)	2.45±0.04 (n=200)	5.09±0.05 (n=200)
***Rhamnus cathartica* L.**, Common Buckthorn	7.34±0.06 (n=255)	3.89±0.02 (n=180)	5.22±0.03 (n=525)

ROSACEAE			
Crataegus phaenopyrum (L. f.) Medik., Washington Hawthorn, Washington Thorn	7.96±0.07 (n=160)	4.91±0.05 (n=150)	4.55±0.03 (n=195)
***Pyrus calleryana* Decne.**, Callery Pear, Bradford Pear	12.49±0.18 (n=115)	2.71±0.12 (n=100)	4.89±0.06 (n=160)
***Rosa multiflora* Murray**, Multiflora Rose, Japanese Rose	7.95±0.10 (n=150)	7.57±0.18 (n=150)	3.91±0.03 (n=350)
Rosa setigera Michx., Prairie Rose, Climbing Rose	9.46±0.10 (n=150)	25.84±0.60 (n=120)	4.23±0.03 (n=330)
SMILACACEAE			
Smilax hispida Raf., [*Smilax tamnoides* L.] Bristly Greenbriar	7.21±0.07 (n=130)	1.12±0.03 (n=130)	4.92±0.07 (n=125)
Smilax lasioneura Hook., Carrion-flower, Blue Ridge Carrionflower	8.91±0.10 (n=125)	3.62±0.14 (n=125)	4.69±0.04 (n=175)
SOLANACEAE			
***Solanum dulcamara* L.**, Bittersweet Nightshade, Climbing Nightshade, Woody Nightshade, European Nightshade	9.79±0.11 (n=150)	30.13±0.70 (n=155)	2.46±0.02 (n=360)
Solanum ptychanthum Dunal, Eastern Black Nightshade, Black Nightshade	7.04±0.06 (n=115)	56.82±0.92 (n=105)	1.45±0.01 (n=225)
VITACEAE			
***Ampelopsis brevipedunculata* (Maxim.) Trautv.**, Porcelain Vine, Amur Peppervine, Porcelainberry	9.02±0.09 (n=155)	2.53±0.08 (n=155)	4.63±0.02 (n=205)
Parthenocissus inserta (A. Kern.) Fritsch[4], [*Parthenocissus vitacea* (Knerr) Hitchc.] Thicket Creeper, Woodbine	7.77±0.07 (n=180)	2.57±0.08 (n=180)	4.49±0.03 (n=275)
Vitis riparia Michx., Riverbank Grape, River-bank Grape	8.45±0.06 (n=225)	2.02±0.06 (n=200)	5.10±0.02 (n=400)

[1]Hybridization between the two previous species is common in Michigan (Voss and Reznicek 2012), and many samples of *R. glabra* had some hybrid characteristics. Thus, combined measurements are also provided here.
[2]Other common shrub honeysuckles are primarily summer fruiting.
[3]Nearly all plants keyed to *L. obtusifolium* Siebold & Zucc., Border Privet, but some had characteristics of *L. vulgare* L., Common Privet (Nesom 2009; Maddox et al. 2010; Voss and Reznicek 2012), so I combined them here.
[4]The very similar species *P. quinquefolia* (L.) Planch. is far less common at my study sites and sets fruit much less frequently.

TABLE 2. Available literature reports of morphometrics of fruits of some of the same species in Table 1. Single values are variously described as diameter, size, length, or longest, shortest, or least dimension. If two values are given for fruit or seed size, these are length or longest dimension and width, diameter, or shortest dimension. See source material for details of the measurements. Locations for each source are given as country or US state; the source material usually provides more specific sites. See Table 1 for common names and nomenclature.

Species and source	Fruit size (mm)	Seed count	Seed size (mm)	Location
ADOXACEAE				
Viburnum opulus				
Herrera 1987	10.2 x 8.9 (n=20-40)	1.0 (n=20-40)		Spain
Snow and Snow 1988	9.0 x 8.4 (n≥10)	1.0 (n≥10)		England
Eriksson and Ehrlén 1991	9.7 (n=25)	1.0 (n=25)		Sweden
Englund 1993	9.3 x 8.3 (n=71)			Sweden
Gervais and Wheelwright 1994	11.0 (n=25)	1.0 (n=25)	7.8 x 7.1 (n=10)	Maine, USA
Whelan et al. 1998	8.9 (n=10)			Illinois, USA
Hampe 2003	10.4			Germany
Hernández 2009	10.16 x 9.28 (n=390), early season		7.84 x 6.67 (n=390), early season	Spain
	10.82 x 9.43 (n=390), late season	8.19 x 6.84 (n=390) late season		
Lee et al. 1991		1.0 (n=200)		England
CUPRESSACEAE				
Juniperus virginiana				
Fassett 1944	4.7 (n=33)			Michigan, USA
	4.6 (n=142)			Massachusetts, USA
McPherson 1987	6.15 x 5.35 (n=10)			Oklahoma, USA
Stapanian 1982		1.67 (n≥40)		Kansas, USA
White 1989		1.2 (n≥10)		New Jersey, USA
ANACARDIACEAE				
Rhus glabra				
Stapanian 1982		1.0 (n≥40)		Kansas, USA
White 1989		1.0 (n≥10)		New Jersey, USA
Li 1999	5.44 x 4.84 (n=50)		3.1 x 2.4 (n=80)	Kentucky, USA
Shelton and Cain 2002		1.0 (n≥20)		Arkansas, USA

Rhus typhina				
White 1989		1.0 (n≥10)		New Jersey, USA
Li 1999, Li et al. 1999			2.7 x 2.1 (n=80)	Tennessee, USA
Toxicodendron radicans				
Johnson et al. 1985 (as *Rhus radicans*)		1.0 (n=15)		Illinois, USA
White 1989		1.0 (n≥10)		New Jersey, USA
AQUIFOLIACEAE				
Ilex verticillata				
White 1989		5.8 (n≥10)		New Jersey, USA
Gervais and Wheelwright 1994	7.7 (n=25)			Maine, USA
CANNABACEAE				
Celtis occidentalis				
Stapanian 1982		1.0 (n≥40)		Kansas, USA
Johnson et al. 1985	9.8 (n=30)	1.0 (n=30)		Illinois, USA
White 1989		1.0 (n≥10)		New Jersey, USA
CAPRIFOLIACEAE				
Lonicera japonica				
White 1989		6.7 (n≥10)		New Jersey, USA
Williams and Karl 1996	5.1 (n≈25)	6.1 (n≈100)		New Zealand
Hidayati et al. 2000			2.89 (n≥50)	Kentucky, USA
Shelton and Cain 2002		6.2 (n≥20)		Arkansas, USA
Kominami et al. 2003				Japan
Takahashi and Kamitani 2004	7.7 (n=100)		2.0	Japan
Greenberg and Walter 2010		4.3 (n=648)		North Carolina, USA
Lonicera maackii				
Whelan et al. 1998	6.7 (n=10)			Illinois, USA
Hidayati et al. 2000			4.24 (n≥50)	Kentucky, USA
Schulz and Wright 2015		3.1 (n=200), low light 4.4 (n=200), high light		Oklahoma, USA

(*Continued*)

TABLE 2. Continued.

Species and source	Fruit size (mm)	Seed count	Seed size (mm)	Location
CELASTRACEAE				
Celastrus orbiculatus				
Patterson 1974		2.8 (n=149)		North Carolina, US
		4.11 (n=163)		Virginia, USA
		3.89 (n=194)		Pennsylvania, USA
		2.48 (n=100)		New Jersey, USA
White 1989		4.8 (n≥10)		New Jersey, USA
Tibbetts 2000		3.68 (n=1,003)		Michigan, USA
Van Clef 2001		4.9 (n=60)		New Jersey, USA
Fukui 2003	7.5 (n≥20)		3.8 (n≥20)	Japan
Kominami et al. 2003	4.9		2.7	Japan
Leicht-Young et al. 2007		4.1 (n=150)		Indiana, USA
Greenberg and Walter 2010		5.0 (n=642)		North Carolina, USA
Masaki et al. 2012	7.4 x 7.0 (n=30)	3.7 (n=30)	4.0 x 2.5 (n=30)	Japan
Celastrus scandens				
Johnson et al. 1985		4.4 (n=10)		Illinois, USA
Tibbetts 2000		2.43 (n=390)		Michigan, USA
Van Clef 2001		3.1 (n=60)		New Jersey, USA
Leicht-Young et al. 2007		2.8 (n=150)		Indiana, USA
Euonymus alatus				
Takahashi and Kamitani 2004, (as *E. alatus* f. *stiatus*)		5.5 (n=100)		Japan
CORNACEAE				
Cornus amomum				
Borowicz 1988			4.4 (n=40)	Pennsylvania, USA
White 1989		1.0 (n≥10)		New Jersey, USA
McCall and Walck 2014		1.0		Tennessee, USA

Cornus drummondii				
Stapanian 1982		1.0 (n≥40)		Kansas, USA
Whelan et al. 1998	7.4 (n=10)			Illinois, USA
Cornus florida				
White 1989		1.0 (n≥10)		New Jersey, USA
Fukui 2003	11.0 (n≥20)		5.3 (n≥20)	Japan
Cornus foemina subsp. *racemosa*				
Johnson et al. 1985 (as *C. racemosa*)	6.39 (n=30)	1.0 (n=130)		Illinois, USA
Borowicz 1988 (as *C. racemosa*)			4.6 (n=40)	Pennsylvania, USA
White 1989 (as *C. racemosa*)		1.0 (n≥10)		New Jersey, USA
Cornus sericea				
Piper 1986 (as *C. stolonifera*)	6.16 (n=100)	1.0 (n=50)		Washington, USA
Traveset et al. 2004 (as *C. stolonifera*)		1.0 (n=40)		Alaska, USA
ELAEAGNACEAE				
Elaeagnus umbellata				
Nakanishi 1996	5.1 x 5.6 (n=10)			Japan
Fukui 2003	10.0 (n≥20)		6.5 (n≥20)	Japan
Kohri et al. 2010	5.5 x 5.3 (n=20)	1.0	5.4 x 2.8 (n=20)	Japan
Maskai et al. 2012	8.8 x 8.4 (n=30)	1.0 (n=30)	6.9 x 3.0 (n=30)	Japan
McCall and Walck 2014	8.8 x 7.57 (n=12)	1.0 (n=12)		Tennessee, USA
LAURACEAE				
Lindera benzoin				
Johnson et al. 1985	8.53 (n=30)	1.0 (n=72)		Illinois, USA
White 1989		1.0 (n≥10)		New Jersey, USA
MENISPERMACEAE				
Menispermum canadense				
Stapanian 1982		1.0 (n≥40)		Kansas, USA
Johnson et al. 1985	7.98 (n=30)	1.0 (n=78)		Illinois, USA

(*Continued*)

TABLE 2. Continued.

Species and source	Fruit size (mm)	Seed count	Seed size (mm)	Location
OLEACEAE				
Ligustrum obtusifolium				
Nakanishi 1996	6.8 x 5.8 (n=10)			Japan
Ligustrum vulgare				
Hererra 1987	7.1 x 6.1 (n=20-40)	1.1 (n=20-40)		Spain
Snow and Snow 1988	8.5 (n≥10)	2.2 (n≥10)		England
Lee et al. 1991		2.5 (n=200)		England
Obeso and Grubb 1993		1.65		England
Shelton and Cain 2002		1.0 (n≥20)		Arkansas, USA
Hampe 2003	7.2			Germany
PHYTOLACCACEAE				
Phytolacca americana				
Stapanian 1982		9.23 (n≥40)		Kansas, USA
McDonnell et al. 1984		9.85 (n=280)		New Jersey, USA
Johnson et al. 1985	7.86 (n=30)	9.68 (n=150)		Illinois, USA
White 1989		9.5 (n≥10)		New Jersey, USA
Whelan et al. 1998	8.9 (n=10)			Illinois, USA
Prather et al. 2000	8.24 (n=100)			Arkansas, USA
Fukui 2003	8.0 (n≥20)		3.0 (n≥20)	Japan
RHAMNACEAE				
Frangula alnus				
Herrera 1987	6.2 x 6.9 (n=20-40)	2.6 (n=20-40)		Spain
Eriksson and Ehrlén 1991	7.8 (n=25)	2.0 (n=25)		Sweden
Medan 1994	7.6 x 8.3 (n=17)			Spain
Hampe and Bairlein 2000	8.3 x 9.0 (n=200)	2.9 (n=200)		Spain
	7.6 x 8.2 (n=110), early season	2.1 (n=110), early season		Germany
	7.6 x 8.3 (n=90), late season	2.4 (n=90), late season		Germany

Hampe 2003	9.4		Germany
Clark 2012	8.31 (n=124)	2.41 (n=124)	Massachusetts, USA
	9.16 (n=151)	2.65 (n=151)	Massachusetts, USA
Bolmgren and Eriksson 2015	8.7 (n=458)	1.7 (n=960)	Sweden
Rhamnus cathartica			
Herrera 1987	6.3 x 7.4 (n=20-40)	3.5 (n=20-40)	Spain
Snow and Snow 1988	8.1 x 8.6 (n≥10)	4.0 (n≥10)	England
White 1989		3.9 (n≥10)	New Jersey, USA
Lee et al. 1991		3.8 (n=200)	England
Whelan et al. 1998	8.1 (n=10)		Illinois, USA
ROSACEAE			
Crataegus phaenopyrum			
White 1989		5.0 (n≥10)	New Jersey, USA
Rosa multiflora			
White 1989		4.6 (n≥10)	New Jersey, USA
Greenberg and Walter 2010		6.5 (n=360)	North Carolina, USA
SMILACACEAE			
Smilax hispida			
Johnson et al. 1985	7.29 (n=30)	1.15 (n=82)	Illinois, USA
Smilax lasioneura			
Johnson et al. 1985	7.73 (n=30)	3.31 (n=120)	Illinois, USA
SOLANACEAE			
Solanum dulcamara			
Herrera 1987	11.0 x 7.7 (n=20-40)	27.6 (n=20-40)	Spain
Snow and Snow 1988	12.2 x 8.6 (n≥10)	26.9 (n≥10)	England
Eriksson and Ehrlén 1991	6.2 (n=25)	17.9 (n=25)	Sweden

(*Continued*)

TABLE 2. Continued.

Species and source	Fruit size (mm)	Seed count	Seed size (mm)	Location
VITACEAE				
Ampelopsis brevipedunculata				
Kominami et al. 2003	5.8		3.4	Japan
Parthenocissus quinquefolia				
Stapanian 1982		2.81 (n≥40)		Kansas, USA
Johnson et al. 1985	7.48 (n=30)	2.1 (n=20)		Illinois, USA
White 1989		3.0 (n≥10)		New Jersey, USA
Van Clef 2001		3.1 (n=60)		New Jersey, USA
Vitis riparia				
Stapanian 1982		2.64 (n≥40)		Kansas, USA
White 1989		2.0 (n≥10)		New Jersey, USA
Whelan et al. 1998	8.3 (n=10)			Illinois, USA

ishi 1996; Flörchinger et al. 2010; Gosper and Vivian-Smith 2010; also summarized in Willson 1986). My sample sizes were also often larger than those provided in the literature; 90% of mine were greater than 100, in contrast to fewer than 25% for measurements reported in the literature.

These data can be used in biogeographical studies, which are considered important in understanding demographic processes and how plants adapt to disturbance or novel environments (Hierro et al. 2005; Wright 2007; Uriarte et al. 2011; Farwig and Berens 2012). In a broader context, knowledge of fruit traits that promote frugivory and subsequent seed dispersal can assist in restoration and conservation efforts by informing managers of how seeds (and thereby the genetic diversity of species) may be dispersed through habitats and alter restoration trajectories (Wright 2007; McConkey et al. 2012; McAlpine et al. 2016) and aiding them in assessing risks from undesirable invasive species (Gosper et al. 2005; Buckley et al. 2006; Gosper and Vivian-Smith 2010; Westcott and Fletcher 2011).

A number of authors have stressed the importance of integrating seed dispersal research, including plant-animal interactions such as the role of frugivorous birds, into conservation practice (Gosper et al. 2005; Wenny et al. 2011; Westcott and Fletcher 2011; McConkey et al. 2012; McAlpine et al. 2016). Based on my literature search, specific data on fruit traits is collected in a wide variety of studies. Compilation of these widely dispersed data increases their exposure and offers valuable opportunities for new insights and collaborations across disciplines.

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PLANTS SEEN AT PRAIRIE DU CHIEN IN 1824–1826: NOTES FROM THE DIARY OF DR. EDWIN JAMES

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ABSTRACT

Dr. Edwin James, botanist of the 1820 Long Expedition to the Rocky Mountains, was commissioned as an assistant surgeon in the U.S. Army Medical Department in January 1823. The following November, he was assigned to Fort Crawford at Prairie du Chien in what is today Crawford County, Wisconsin, where he spent the next three years. When not occupied with medical duties, he studied the local flora, recording in his personal diary notes on plants seen in the area. This diary, which has never been published, was examined and all botanical notes made during James' tenure at Fort Crawford compiled. The resulting list of taxa he noted there comprises 53 species, including four naturalized European ruderals and three natives that had not yet been named or described when James saw them.

KEYWORDS: Botanical history, Edwin James, Wisconsin flora.

INTRODUCTION

The name of Dr. Edwin James (1797–1861) is best known to botanists for his participation in the 1820 Long Expedition to the Rocky Mountains (Browning 1918; Osterhout 1920; Wood 1966; Nichols and Halley 1980; Benson 1988; Evans 1997). Once he had completed writing up the results of that expedition (James 1822, 1823, 1825), he never again published on botanical topics. However, his interest in botany did not end there.

Between 1823 and 1832, James served as an Army surgeon at three posts in the Territory of Michigan, where he continued to pursue botanical studies (Benson 1968). For example, while stationed on Mackinac Island during the summer of 1827, he collected the specimen upon which Eaton (1829: 180) based his description of *Cnicus pitcheri* Torr. ex Eaton [≡*Cirsium pitcheri* (Torr. ex Eaton) Torr. & A. Gray; Voss 1956, 1978, 2001]. Prior to that, James had been stationed at Prairie du Chien, where he recorded numerous notes on local plants in his diary. This volume (denoted as "James Diary" in the Literature Cited) has never been published.

I obtained a microfilm copy of James' diary and have extracted from it his observations on the plants of Prairie du Chien. From this I have compiled a list of the taxa he noted. As with another paper, which details James' activities in Iowa (Lammers, 2016), this is intended as an adjunct to the thorough delineation of James' Long Expedition collections prepared by Goodman and Lawson (1995).

ASSISTANT SURGEON, U.S. ARMY

James relished his adventures in the West with Maj. Stephen Harriman Long (1784–1864) of the U.S. Army Corps of Engineers. Advised by Long that a military officer would have a better chance than a civilian to participate in further explorations, James wrote to Secretary of War John Caldwell Calhoun (1782–1850) requesting an appointment to the Army Medical Department (Ayars 1922; Benson 1968; Gillett 1987). On January 4, 1823, Calhoun forwarded to President James Monroe (1758–1831) a list of nominations that included James' name. Monroe sent the nominations to the Senate on January 15, where they were referred to the Committee on Military Affairs. That committee reported favorably and on January 27, James received a commission in the United States Army at the rank of assistant surgeon (Nourse 1825; Anonymous 1828). His first assignment was to Fort Bellefontaine, located on the Missouri River north of St. Louis, Missouri.

While all this was going on, Long was preparing for a new expedition, this time to the valley of the Minnesota River. Pleased with James' prior service, he requested that the newly commissioned assistant surgeon be assigned to his party as botanist and medical officer (Keating 1824; Wood 1955; 1966). Unfortunately, by the time orders were cut and transmitted, James already had departed for Missouri (Shear and Stevens 1921). Attempts to intercept him failed, and he arrived in St. Louis on June 3, 1823, by which time Long's party was traversing northern Indiana (Keating 1824).

Fort Bellefontaine was merely a temporary assignment. Two months after his arrival, James was ordered to report for duty at Fort Crawford in Prairie du Chien, Michigan Territory. While en route, he suffered a relapse of the malaria he had contracted on the Long Expedition. He halted to recuperate at Fort Armstrong near Rock Island, Illinois, and did not reach his new post until November 15, 1823 (Benson 1968).

FORT CRAWFORD

Prairie du Chien is situated on the banks of the Mississippi River, two miles north of the mouth of the Wisconsin River in Crawford County, Wisconsin. Euro-American occupation has been continuous since 1685, when Nicolas Perrot (1644–1717) established a post at which he traded for furs with indigenous trappers (Twinde-Javner 2009). An American military presence began in June 1814 when a detachment of the Seventh Infantry Regiment built Fort Shelby on St. Feriole Island (Nourse 1825; Mahan 1926). Only a month later, the fort fell to British forces, who occupied it and renamed it Fort McKay. They razed the fort in May 1815 when the region was returned to American suzerainty under the Treaty of Ghent (*8 Stat. 218*).

In June 1816, six companies of the Regiment of Riflemen came to Prairie du Chien to rebuild. A new fort, named in honor of Secretary of War William Harris Crawford (1772–1834), was built upon the ruins of Fort Shelby. It was con-

structed entirely of wood, save a powder magazine of quarried stone. The outer walls formed a hollow square 340 ft on a side and 20 ft tall, with two-story blockhouses at the northwestern and southeastern corners (Lockwood 1856; Long 1860; Mahan 1926; Twinde-Javner 2009). When James arrived seven years later, the post was garrisoned by Companies G and K of the Fifth Infantry Regiment (approximately 70 men; Brown 1825) under the command of Lt. Col. Willoughby Morgan (1785–1832).

Most of the health problems that James was called upon to treat in his three-room hospital were related to the fort's setting in an expansive riparian wetland (Benson 1968). Poor drainage meant that drinking water too often was contaminated by human waste, resulting in diarrhea, dysentery, and even cholera. These wetlands were also the habitat of *Anopheles quadrimaculatus* Say, the dipteran vector of the parasitic apicomplexan *Plasmodium falciparum* (Wm. H. Welch), the cause of malaria. On September 15, 1824, James was sent down to the mouth of the Galena River in Illinois to tend to Col. John Anderson, a topographer with the Corps of Engineers, who was "extremely ill of bilious fever" (James Diary: 340–341).

In the summer of 1825, Superintendent of Indian Affairs William Clark (1770–1838) and Governor Lewis Cass (1782–1866) invited to Prairie du Chien representatives of all indigenous nations in the upper Mississippi valley and the western Great Lakes. Thousands of Dakota, Ho-Chunk, Sauk, Meskwaki, Ojibwe, Odawa, Potawatomi, Menominee, and Iowa responded, forming one of the largest conclaves of indigenous peoples ever assembled in North America (Abele 1969). In an effort to ensure peace in the region, the representatives on August 19, 1825 signed the Treaty of Prairie du Chien (*7 Stat. 272*), which established clear boundaries among their lands (James Diary: 355).

When the War Department decided to close Fort Crawford in 1826, most of the soldiers were sent up the Mississippi to Fort Snelling at the mouth of the Minnesota River (Twinde-Javner 2009). James however was ordered to duty at Fort Brady near the eastern end of Lake Superior in Sault Sainte Marie, Michigan Territory. He left for his new assignment on 17 October 1826. When Fort Crawford reopened the following year, James' replacement there was Dr. William Beaumont (1785–1853), the surgeon who was then using the badly healed stomach wound of Alexis Bidagan St. Martin (1802–1880) to explore gastric function (Beaumont 1833; Horsman 1996).

JAMES' BOTANICAL ACTIVITIES

When James learned that he had missed out on Long's second expedition, he wrote to Maj. Isaac Roberdeau (1763–1829), Chief of the Topographical Bureau at the Corps of Engineers, suggesting that he be placed in charge of his own scientific expedition to the West (Wood 1955; Benson 1968). While Roberdeau expressed interest in the detailed plans that James submitted, nothing came of them. Secretary Calhoun, however, did point out to James that he was free to

conduct botanical studies in the vicinity of his post, as long as doing so did not interfere with his assigned duties.

As a result, James commenced an examination of the local flora early the next spring, recording his observations in the same diary that he had kept during the Long Expedition. All of the species he recorded during his three years of duty at Fort Crawford are listed below.

A typical botanical entry in James' diary consisted of nothing more than the plant's name and the date seen. When the scientific name used by James differs from that in current use, the former is given in square brackets. A few years after leaving Fort Crawford, James (1830) published a list of Ojibwe names for plants in the region. When a species mentioned in his diary also appeared on that list, the Ojibwe name noted by James is cited below. If James made additional comments, they are quoted here. All elisions within these quotes are due to damage that rendered the text indecipherable. Pages in James' diary are unnumbered; the inferred page numbers given here in the citations are concordant with those of Benson (1968). Any comments regarding the current distribution of a species in Wisconsin are derived from Wisconsin State Herbarium (2016).

Acer saccharinum L. [as *A. dasycarpum* Ehrh.] Ojibwe name: "she-she-gum-maw-wis" (James 1830: 294).—"in flower," March 20, 1825 (James Diary: 352).

Actaea rubra (Aiton) Willd. [as *A. americana* (Aiton) Pursh, *nom. illeg.*]—May 19, 1824 (James Diary: 325).

Anemone acutiloba (DC.) G. Lawson [as *Hepatica triloba* Chaix]—"fully in flower … some days before [April 23, 1826]" (James Diary: 373).

Anemone patens L. var. **multifida** Pritzel [as *A. ludoviciana* Nutt.]—"The early ornament of the sandy plains about Prairie du Chien is called by the French . . . the March rose. The root of it is said to be sometimes used by the aborigines as a . . . flower appears before any of the leaves are expanded. It grows in tufts and clusters and is produced in very great abundance," *ante* 29 April 1824 (James Diary: 319). "The Anemone ludoviciana was fully in flower on the 23rd [of April 1826]" (James Diary: 373).

Antennaria plantaginifolia (L.) Hook. [as *Gnaphalium plantaginifolium* L.]—May 8, 1824 (James Diary: 322).

Arabidopsis lyrata (L.) O'Kane & Al-Shehbaz [as "an Arabis"]—"the bluffs on the east side of the Mississippi," April 29, 1824 (James Diary: 320). Seven species of *Arabis* L. *sens. lat.* [including *Arabidopsis* (DC.) Heynh., *Boechera* Á. Löve & D. Löve, and *Turritis* L.] occur in the region; the identity of James' species is inferred here from phenology and habitat.

Aralia nudicaulis L.—May 19, 1824 (James Diary: 325).

Arisaema triphylla (L.) Schott [as *Arum triphyllum* L.]—See *Juniperus communis.*

Aronia melanocarpa (Michx.) Ell. [as *Crataegus pyrifolia* Lam.]—May 24, 1824 (James Diary: 325). *Crataegus pyrifolia* is properly a synonym of *Aronia arbutifolia* (L.) Pers., but that is a southeastern species that does not reach the western Great Lakes.

Caltha palustris L.—May 17, 1824 (James Diary: 324). See also *Juniperus communis.*

Capsella bursa-pastoris (L.) Medik. [as *Thlaspi bursa-pastoris* L.]—May 8, 1824 (James Diary: 322).

Carex plantaginea Lam.—May 28, 1824 (James Diary: 326).

Castilleja coccinea (L.) Spreng. [as *Euchroma coccinea* (L.) Nutt.]—May 21, 1824 (James Diary: 325).

Claytonia virginica L.—May 24, 1824 (James Diary: 325).

Comandra umbellata (L.) Nutt. [as *Thesium umbellatum* L.]—May 21, 1824 (James Diary: 325).

Corydalis micrantha (Engelm. ex A. Gray) A. Gray—"A unicalcarate species of Corydalis began to appear in flower in the old fields (originally prairies) immediately about the garrison. It appears to differ in some aspects from the C. aurea of Pursh as does also the small flowering and very leafy species which I observed four years since in the Mississippi bottoms below Cape Girardeau.

These two ... yellow flowering species differing very essentially from the Perizomanthi of Pursh [i.e., *Dicentra* Bernh.] may have escaped the attention of botanists; at least they appear not to have been clearly described. The present plant is ... sending up from a small fusiform root a number of assurgent nearly simple stems bearing the flowers in a terminal spike. The leaves are pinnate with gashed and pinnatifid divisions. Stipules ovate acuminate and slightly denticulate – longer than the peduncle. The flowers about twice as large as those of the other yellow species but less than any of those with two spurs. The leaves are small and their color in conjunction with the ascending yellow spikes gives the plant a distinct resemblance to the Antirrhinum Linaria [i.e., *Linaria vulgaris* Mill.] so common in old fields around Albany," May 12, 1824 (James Diary: 322–323). The only yellow-flowered species of *Corydalis* DC. in Wisconsin besides *C. aurea* Willd. is *C. micrantha.* James' extensive notes suggest that he believed this to represent an undescribed species, which was indeed the case. *Corydalis micrantha* was not described formally until christened as a variety of *C. aurea* by Gray (1867). As for the congener in southeastern Missouri, that likely was *C. flavula* (Raf.) DC.

Cryptotaenia canadensis (L.) DC. [as *Sison canadense* L.]—May 21, 1824 (James Diary: 325).

Cypripedium parviflorum var. **pubescens** (Willd.) O.W. Knight [as *C. pubescens* Willd.]—May 19, 1824 (James Diary: 325).

Dicentra cucullaria (L.) Bernh. [as *Corydalis cucullaria* (L.) Pers.]—"the bluffs on the east side of the Mississippi," April 29, 1824 (James Diary: 320).

Euphorbia corollata L.—"A delicate erect species of Euphorbia is very frequent in the prairies, flowering about the end of August [1824] and whitening the plains for an extent of many miles. It is used by the Indians as an emetic" (James Diary: 340). "In collecting some seeds [for the Columbian Institute], in the prairie near the garrison I observed what was before unknown to me, namely that the seed vessels of the species of Euphorbia used as an emetic medicine by the Indians, when fully ripe burst with an elastic spring like those of the genus Impatiens," Sep 1826 (James Diary: 382). Three erect species of *Euphorbia* L. *sens. lat.* would have been present in the region at that time; this one fits James' description better than *E. cyathophora* Murr. or *E. dentata* Michx.

Fragaria virginiana Mill. Ojibwe name: "o-da-na-me-na-gaw-wun-zheen" (James 1830: 299).—May 16, 1824 (James Diary: 324).

Helenium autumnale L.—"The disc florets of the Helenium autumnale, which grows in great abundance in overflowed grounds about Prairie du Chien was [*sic*] used by the indians as snuff as a remedy for head ache, and are said to excite violent sneezing," Sep 1824 (James Diary: 339).

Hydrophyllum appendiculatum Michx.—May 28, 1824 (James Diary: 325).

Juniperus communis L. Ojibwe name: "kaw-waw-zheek" (James 1830: 294).—"In returning from Fort Snelling early in the spring [of 1826] I ascended the bluffs in several places above and below [Lake Pepin]. On one of the sharp semiconic hills which I ascended and which appeared to me to reach at least double the elevation of Pike's hill (say 1000 ft) I found the Juniperus communis, J. virginiana and Thuja occidentalis growing together in the clefts of the rocks and at the base the Caltha palustris, Pothos foetida, Arum tryphillum [*sic*], &c. &c." (James Diary: 374). Perhaps this was Five Mile Bluff, which stands at the downstream end of Lake Pepin in Pepin County at the mouth of the Chippewa River. "Pike's hill" is now Pike's Peak, across the Mississippi at McGregor in Clayton County, Iowa.

Juniperus virginiana L. Ojibwe name: "mish-kwaw-wauk" (James 1830: 294).—See *Juniperus communis.*

Lithospermum incisum Lehm. [as *Batschia longiflora* Pursh]—May 16, 1824 (James Diary: 324).

Osmunda cinnamomea L.—May 24, 1824 (James Diary: 325).

Packera plattensis (Nutt.) W. A. Weber & Á. Löve—"A Senecio was at this time in flower in the prairies about the garrison but the name of the species I could not satisfactorily ascertain. It rises from one foot to three in height and is terminated by a somewhat fastigiate cluster of yellow flowers so large as to be very conspicuous at a distance. Stems peduncles and scales of the calyx tomentose. Lower leaves petioled deeply and acutely serrate or pinnatifid, the terminal division hastate. Cauline leaves rather . . . lanceolate and pinnatifid," May 28, 1824 (James Diary: 325–326). Three species of *Senecio* L. *sens. lat.* [including *Packera* Á. Löve & D. Löve and *Tephroseris* (Rchb.) Rchb.] are native to the region; this one conforms to James' description better than *P. aurea* (L.) Á. Löve & D. Löve or *P. paupercula* (Michx.) Á. Löve & D. Löve.

Panax trifolium L.—May 24, 1824 (James Diary: 325).

Pedicularis lanceolata Michx. [as *P. pallida* Pursh, *nom. illeg.*]—May 21, 1824 (James Diary: 325).

Poa compressa L.—May 28, 1824 (James Diary: 326).

Podophyllum peltatum L.—May 28, 1824 (James Diary: 325).

Polygala senega L.—May 24, 1824 (James Diary: 325).

Polygala L.—"There are also about at the same time [the end of August 1824] two very beautiful purple flowering species of Polygala which I do not recollect to have seen in any other country" (James Diary: 340). Purple-flowered species in southwestern Wisconsin are *P. incarnata* L., *P. polygama* Walt., and *P. sanguinea* L. James (1821) had seen none of these in Vermont, but had collected *P. incarnata* and *P. sanguinea* during the initial portion of the Long Expedition (James 1825).

Prunus serotina Ehrh. Ojibwe name: "buh-wi-me-nah-ne-ga-wunje" (James 1830: 294).—May 26, 1824 (James Diary: 325).

Prunus L.—May 16, 1824 (James Diary: 324). Five additional native species are found in the region: *P. americana* Marsh., *P. nigra* Ait., *P. pensylvanica* L.f., *P. pumila* L., and *P. virginiana* L.

Pyrus ioensis (Alph. Wood) L. H. Bailey [as *P. coronaria* L.] Ojibwe name: "mish-she-min-nuh-ga-wunje" (James 1830: 295).—May 26, 1824 (James Diary: 325). In James' day this was an undescribed species, first christened as a variety of *P. coronaria* by Wood (1861).

Ranunculus hispidus Michx.—"A species of Ranunculus, much resembling that near Albany, which I formerly thought to be the R. intermedius of Rees' Cyclopedia. It is not described by Pursh but is undoubtedly the same plant which is common in the East," May 19, 1824 (James Diary: 325). *Ranunculus intermedius* Poir. is a synonym of *R. repens* L., a European species; James (1825) reported it (as "R. intermedius? *Smith, in Ree's Encycl.*") from the confluence of the Mississippi and Ohio Rivers. Of the six terrestrial species of *Ranunculus* L. around Prairie du Chien, this one would be most similar to *R. repens*.

Ranunculus rhomboideus Goldie—"A small Ranunculus was in flower on the prairies. The leaves multifid inclining to pinnate. I do not recollect to have seen the plant before but it is too little advanced satisfactorily to determine the species," April 30, 1824 (James Diary: 320). "On the 10th of March [1825] the small Ranunculus was in flower. In the preceding year not seen before the 19th of April" (James Diary: 352). "On the 13th of April [1826] the small Ranunculus was in flower. The year before it had appeared on the 10th of March and the year before that on the 19th of April," (James Diary: 371). Of the eight terrestrial species of *Ranunculus* in the region, this one conforms best to the information provided. James' inability to identify it likely was due to the fact that it had been named just two years earlier (Goldie 1822). It was not among the species James had seen in Vermont (James 1821) or on the Long Expedition (James 1825; Goodman and Lawson 1995).

Ribes L.—May 16, 1824 (James Diary: 324). Native species in southwestern Wisconsin include *R. americanum* Mill., *R. cynosbati* L., *R. hirtellum* Michx., and *R. missouriense* Nutt.

Sanguinaria canadensis L. Ojibwe name: "mis-kwe-wis-che-be-kug-guk" (James 1830: 298).—"the bluffs on the east side of the Mississippi," April 29, 1824 (James Diary: 320).

Silene antirrhina L.—"There is also a slender Decandrous plant with an ovate or inflated calyx and small purplish white flowers which are expanded early in the morning but close during the heat of the day. It is a Cucubalus or Silene but what species I cannot determine," 28 May 1824 (James Diary: 326). Of the three species of *Silene* L. (including *Cucubalus* L.) that are native to the region, this one conforms to James' description better than *S. nivea* (Nutt.) Muhl. ex Otth or *S. stellata* (L.) W. T. Aiton.

Smilax herbacea L.—May 19, 1824 (James Diary: 325).

Symplocarpus foetidus (L.) Salisb. [as *Pothos foetidus* (L.) Aiton]—See *Juniperus communis*.

Taraxacum officinale F. H. Wigg. [as *Leontodon taraxacum* L.]—May 8, 1824 (James Diary: 322).

Thalictrum dasycarpum Fisch. & Avé-Lall. [as *Thalictrum cornuti* L.]—May 19, 1824 (James Diary: 325). This was not described until many years after James saw it (Anonymous 1842). He had misidentified it in the same fashion when he saw it in Vermont (James 1821) and during the Long Expedition (James 1825, Goodman and Lawson 1995).

Thalictrum dioicum L.—"a very small Thalictrum not a foot high with greenish purple flowers in terminal leafy panicles. Probably T. dioicum," May 19, 1824 (James Diary: 325).

Thuja occidentalis L. Ojibwe name: "ke-zhik" (James 1830: 294).—See *Juniperus communis*.

Veronica arvensis L.—May 17, 1824 (James Diary: 324).

Veronica peregrina L.—May 17, 1824 (James Diary: 324).

Viola pedata L.—"occurs in great plenty in the dry, sandy plains and bears a profusion of large flowers," May 16, 1824 (James Diary: 324).

Zizania aquatica L. Ojibwe name: "mah-nom-o-ne-gah-wah-zheen" (James 1830: 298).—"In early September [1824] a few Rail were seen in the grassy marshes and especially where the wild rice is found in abundance" (James Diary: 338). Below the mouth of the Wisconsin River, "I waded about thru many of the shallow ponds which are so common on the islands of the Mississippi. Most of these are filled with the gigantic stalks of the Zizania aquatica rising like a little forest eight or ten feet above the surface, at this time heavily loaded with grain and affording food to countless thousands of ducks geese and other kinds now on their annual journey from the shores of Hudson bay to the Gulf of Mexico," Sep–Oct 1824 (James Diary: 345–346).

SIGNIFICANCE

The total number of entries in James' diary that mentioned plants around Prairie du Chien during 1824–1826 was 53. Some mentioned one species, others more (e.g., the entry on page 374), while some species appeared in multiple entries (e.g., *Ranunculus rhomboideus*). Despite these irregularities, the total number of species noted in these entries was coincidentally 53. One was a fern, three were conifers, and the rest angiosperms (seven monocots, 42 dicots).

James' unpublished notes on plants of Prairie du Chien represent some of the very earliest records on the flora of Wisconsin (Cheney 1900, 1901). The only botanist to visit Prairie du Chien prior to James was Thomas Nuttall (1786–1859), who came down the Wisconsin River from the Fox River portage in 1810 (Pennell 1936; Graustein 1951; Stuckey 1967). Nuttall (1818) gave Prairie du Chien as a locality for just six species: *Amorpha canescens* Pursh, *Artemisia serrata* Nutt., *Castilleja sessiliflora* Pursh [as *Euchroma grandiflora* Nutt.], *Dalea enneandra* Nutt. [as *D. laxiflora* Pursh], *Lithospermum incisum* Lehm. [as *Batschia longiflora* Pursh], and *Penstemon grandiflorum* Nutt. The *Lithospermum* was the only one also noted by James.

Of particular interest are the four ruderal species noted by James that are not native to North America: *Capsella bursa-pastoris, Poa compressa, Taraxacum officinale,* and *Veronica arvensis*. As early as 1824, anthropogenic activity had introduced disseminules of these European species to a wilderness area beyond the frontier, in a region yet to undergo agricultural and urban settlement. Furthermore, the environment around Prairie du Chien already had been disturbed enough to create habitat for these species. One can only wonder how soon these species had actually arrived after Perrot erected his trading post in 1685. Had they already been established a century or more when James saw them?

Also of interest are the species that were as yet undescribed and unnamed when seen by James: *Corydalis micrantha, Pyrus ioensis,* and *Thalictrum dasycarpum.* James had baptized a handful of species prior to this, e.g., *Aquilegia coerulea* E. James, *Geranium caespitosum* E. James, *Pinus flexilis* E. James. Had he gone to print with these three novelties from Prairie du Chien, the names bestowed by him would have had priority.

FROM BOTANY TO LINGUISTICS

Although diary entries about plants were made throughout James' three-year tenure at Fort Crawford, they were most numerous at the very beginning of his first growing season there. Forty-one (77%) of the 53 entries were dated in just two months, April and May 1824. The 12 remaining entries were spread over 19 months.

Several factors likely account for this pattern of decreasing activity. As noted above, the fort was situated in an environment that promoted a variety of illnesses among the troops. Not only was James kept busy ministering to the stricken, he himself suffered extended bouts of ill health (Benson 1968). For example, on September 1, 1826, James received from Surgeon General Dr. Joseph Lovell (1788–1836) a request on behalf of the Columbian Institute for the Promotion of Arts and Sciences for "specimens of seeds, plants, minerals, fossils, or whatever may be deemed useful and interesting" (Rathbun 1917: 59). However, "my health being poor, and the autumnal fevers prevailing to considerable extent in the garrison and the settlement I was unable for some time to give any attention to this subject" (James Diary: 382).

As the number of botanical comments in James' diary decreased, entries detailing his interactions with the indigenous Ho-Chunk, Ojibwe, and Menominee became more common. His interest in plants was soon crowded aside by a profound interest in indigenous languages. By the time he departed Fort Crawford, this shift in scholarly pursuits was all but complete. En route to his new posting at Fort Brady in early 1827, James visited cities in the East. In Philadelphia he called upon the foremost American linguist of the day, Pierre-Étienne du Ponceau (1760–1844), presenting him with a copy of notes he had made on Menominee language and culture (Benson 1968). At the New York Historical Society, he delivered a paper on the mythology of the Algonquian peoples (Anonymous 1827a, 1827b).

That summer at Fort Mackinac near the western end of Lake Huron, James met John Tanner (1780–1846), a child-abductee who had grown to adulthood among the Ojibwe and become thoroughly acculturated (Harmon 1820, Keating 1824). At Fort Brady, James helped Tanner publish an account of unique upbringing (James 1830; Anonymous 1830a, 1830b; Rafinesque 1832) and with Tanner's assistance translated the New Testament from Greek (Knapp 1829) into Ojibwe (James 1833a; Anonymous 1833a, 1833b). A by-product of this work was the publication of a series of Ojibwe grammars and lexicons (James 1832, 1833b, 1833c, 1835). James never again published on botany.

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ADDITIONS TO THE FLORA OF BEAVER ISLAND, CHARLEVOIX COUNTY, MICHIGAN

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ABSTRACT

Fifty species of vascular plants collected on Beaver Island are presented as new records for the Island, which is part of Charlevoix County, Michigan. Forty-nine of the species are new records for the entire Beaver Island Archipelago, and one, which was previously known on the archipelago (Carex buxbaumii), is a new record for Beaver Island itself. They include taxa from among pteridophytes, gymnosperms, and flowering plants. Twenty of the newly reported species are non-native. Eight hundred twelve vascular plants have now been recorded for the Beaver Island Archipelago.

KEYWORDS: Beaver Island, Charlevoix County, vascular plants, new records.

INTRODUCTION

The upper Great Lakes area, with its varied flora, has long been known to be botanically interesting. Voss (1972, 1985, 1996) and Voss and Reznicek (2012) have shown that the Beaver Island Archipelago exemplifies this. Several articles detailing aspects of the flora of the archipelago's ten islands (Beaver, High, Garden, Hog, Gull, Trout, Whiskey, Squaw, Hat, and Pismier) have included reports of the pteridophytes (Veldman and Wujek 1971), a sedge (Menapace and Wujek 1987), the flora of the archipelago's most northern island, Hog Island (Whately et al. 2005), and more recently an illustrated guide to plants of the bogs and fens and the Lake Michigan beaches on Beaver Island (Leuck and Wujek 2007).

The present contribution reports additions to the flora of Beaver Island itself. An updated list of the species previously reported for Beaver Island and the archipelago is available at MICHIGAN FLORA ONLINE (2011).

METHODS

Plants were collected over time in various courses the authors have taught on the island since 1969, on nature walks in conjunction with numerous groups, or brought to our attention by an islander or as part of a student collection. Voucher specimens for all of the taxa listed below are housed

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in the herbarium at Central Michigan University (CMC). All voucher specimens are digitized and available for viewing online at Consortium of Midwest Herbaria (2016). Nomenclature follows Voss and Reznicek (2012) for gymnosperms and angiosperms, and MICHIGAN FLORA ONLINE (2011) for ferns and lycopods.

RESULTS

Fifty new vascular plant species are reported for Beaver Island and are listed below. Of these, 49 are also new reports for the archipelago as a whole. Twenty are non-native species and are indicated by an asterisk. The CMC accession number (in parentheses) follows the collector's number.

PTERIDOPHYTES

LYCOPODIACEAE

Lycopodiella inundata (L.) Holub (Bog Clubmoss) Hohn *s.n.* (CMC 0219) July 30, 1973). It is localized at only one specific area on the *Sphagnum* mat on the southwestern edge of Green's Lake bog.

GYMNOSPERMS

PINACEAE

**Picea abies* (L.) Karst. (Norway Spruce) Leuck 2003 (CMU 18245) July 25, 2010. Trees are located at various home sites in northern third of the island. A plantation of them exists in the meadow on the north side of Green's Lake.

**Pinus sylvestris* L. (Scots Pine) Leuck 1654 (CMC 18009) July 28, 1997. Scattered plants were originally observed at the central and north end of the island. Now, however, they have invaded all areas of the island.

MONOCOTYLEDONS

ALISMATACEAE

Alisma triviale Pursh (Northern Water-Plantain) Wujek *s.n.* (CMC 17465) 2 July 29, 2003. This species was first noted in 1995 (Wujek, personal observation) when a single plant was observed growing on top of a beaver lodge along the southeast shore of Fox Lake. It has now become widely dispersed at the northwestern corner of the lake and to several others of the inland lakes.

ARACEAE

Lemna turionifera Landolt (Duckweed) NSF Group *s.n.* (CMC 2851) July 5, 1965. Very localized on small ponds and several inland lake backwaters.

CYPERACEAE

Carex buxbaumii Wahl. (Buxbaum's Sedge) Wujek *s.n.* (CMC 15740) July 10. 1985. Although first reported for the archipelago from Hog Island (Whately et al. 2005), it had been observed earlier (1970) from Beaver Island, but not collected (Wujek, personal observation). Common on the road behind Donegal Bay.

Carex concinna R. Br. (Beauty/Low Northern Sedge) Wujek *s.n.* (CMC 18573) July 30, 1997. Observed initially along the stony calcareous shore of Indian Harbor on Garden Island, it was subsequently collected at Donegal Bay and Gull Harbor on Beaver Island.

LILACEAE

Streptopus amplexifolius (L.) DC (Twisted-stalk) Wujek-Field Botany *s.n.* (CMC 13132) July 22, 1993. Very scattered in the understory along the island's east side in the deciduous or mixed forests.

ORCHIDACEAE

**Epipactis helleborine* (L.) Crantz (Helleborine) J. Pung *s.n.* (CMC 18573) October 31, 1999. First observed growing at the blow-out on Font Lake in 1985 (Wujek, personal observation), it is now widely distributed on the island.

POACEAE

Leersia oryzoides (L.) Sw. (Cut Grass) Wujek *s.n.* (CMC 14064) July 27, 1989. This grass apparently did not occur on the island until after 1979. In that year Jaworski's (1979) survey of the island's grasses did not report its presence. Since it was originally observed in the flood plain of the Jordan River it has spread throughout the island's wetlands.

POTAMOGETONACEAE

**Potamogeton crispus* L. (Curly Pondweed) Pajunen, Calhoun & Walrad 184 (CMC 17928) July 15, 1970. The species was first observed in St. James Harbor in the late 1960s, and has now spread to most of the inland lakes.

DICTOTYLEDONS

APIACEAE

Zizia aurea (L.) Koch. (Golden Alexanders) Wujek *s.n.* (CMU 18577) Aug. 8, 2010. It is in the open meadows along Hannigan and McCauley roads that often remain wet except in late summer.

ASTERACEAE

**Cichorium intybus* L. (Chicory) Wujek *s.n.* (CMC 15775) July 21, 2003. A single roadside plant was originally observed at the junction of King's Highway and McCauley Road. Two populations can be observed along the east and western ends of McCauley Road.

Heliopsis helianthoides (L.) Sweet (False Sunflower) Wujek *s.n.* (CMC 15783) July 17, 2003. A large population can be observed in the open meadows on the north side of Hannigan Road.

Prenanthes racemosa Michx. (Glaucous White Lettuce) Leuck 1579 (CMC 18008) September 9, 1995. A small population exists behind Donegal Bay.

**Tragopogon pratensis* L. (Common Goat's-beard) Wujek *s.n.* (CMC 15601) July 23, 2003. Small populations are distributed throughout the island's open meadows.

BERBERIDACEAE

Caulophyllum thalictroides (L.) Michx. (Blue Cohosh) Leuck *s.n.* (CMC 22518) July 24, 2014. Although previously reported elsewhere in the Beaver Island archipelago (Hog Island, Whately et al. 2005), our specimen represents its first record for Beaver Island itself where it grows in the forested interdunal swales west of Barney's Lake.

BIGNONIACEAE

**Catalpa speciosa* Warder (Northern Catalpa) Schreiber *s.n.* (CMC 18011) August 1, 1969. It was planted in a front yard of a home in town along with several horse-chestnuts. Our specimen represents the northern-most record for Michigan.

BRASSICACEAE

Alliaria petiolata (Bieb.) Cavara & Grande (Garlic Mustard) Wujek *s.n.* (CMC 18578) Sept. 9, 2010. To date the only specimens observed have been in the St. James Township Campground. Seeds undoubtedly were brought over from the mainland by campers. It was also observed growing in the yard of one of St. James businesses.

CANNABACEAE

**Cannabis sativa* L. (Marijuana) Wujek *s.n.* July 27, 1976. Although this species is not "cultivated" on the island, thirteen specimens were collected from a ring of young plants surrounding a fire-pit at Gull Harbor where it probably had been "passed around." Specimens collected were placed in the CMC herbarium, but owing to the herbarium's openness in its early days, voucher specimens have disappeared. Only one 35mm slide of plants taken at the time of collection exists and has been placed in the CMC herbarium.

*Humulus lupulus (*Hops) Wujek 125 (CMC 17127) July 19, 1996. Price (1976) indicates that this was grown at the northern end of the island by the late F. Protar, who was considered

the island's doctor in the late 1890s – early 1900s although he had no medical training. Two additional locations are from the central and southern regions of the island where it has been collected (base of Angeline Bluff going to French Bay and at the intersection of Kings Highway and Hannigan Road). These populations more than likely originated from Protar's original planting at his residence at the western end of Sloptown Road when he was the island's "doctor" at the turn of the 20th century when he was using it for medicinal purposes

CAPRIFOLIACEAE

**Lonicera morrowii* A. Gray (Morrow's Honeysuckle) Leuck 1440 (CMU 23105) September 7, 1990. Both this species and *L. tartarica* can be observed primarily in St. James Township in disturbed areas and the fore dunes of Lake Michigan.

**Lonicera tartarica* L. (Tartarian Honeysuckle) Leuck 1212 (CMC 23107) July, 1971

CARYOPHYLLACEAE

Dianthus ameria L. (Deptford Pink) K. Peschel *s.n.* (CMC 12689) July 18, 1972. It is prevalent in open fields throughout the island.

**Gypsophila paniculata* L. (Baby's Breath) Leuck *s.n.* (CMC 23112) July 22, 2015. Three persistent plants were collected at the margin of the mown grass on the lakeshore at Whiskey Point lighthouse, St. James. A large population has also been observed on High Island (Leuck 2015, personnel observation).

CELASTRACEAE

**Celastrus orbiculatus* Thunb. (Oriental Bittersweet) Leuck *s.n.* (CMC 23116) July 27, 2015. Although previously reported from the mainland of Cheboygan County (Dorey et al. 2011), it has not been previously reported from the island. Collected along the northern end of Lake Michigan's shoreline; weed clambering over herbaceous vegetation and small trees, north side of St. James Harbor near Whiskey Point lighthouse. Also observed older vines were observed growing along East Shore Drive among a population of Japanese knotweed (Leuck, personal observation).

CORNACEAE

Cornus alternifolia L. (Alternate-leaved Dogwood) Leuck *s.n.* (CMC 23108) June 29, 2013. Only one population has been observed: Bonner's Bluff above French Bay. *Cornus alternifolia* represents the fifth *Cornus* taxon to be collected from Beaver Island.

ELAEAGNACEAE

**Elaeagnus umbellata* Thumb. (Autumn-olive) Leuck 2004 (CMC 18241) July 27, 2010. It has become an aggressive invasive in the island's meadows and forest margins.

ERICACEAE

Pyrola chlorantha Sw. (Shinleaf) Roush *s.n.* (CMC 17396). Only one population has been observed: west side of East Side Drive near Conn's Point in the mixed forest among the moss and litter.

EUPHORBIACEAE

Euphorbia corollata L. (Flowering Spurge) Wujek *s.n.* (CMC 16949) July 19, 1996. We have observed it growing along Hannigan Road and Kings Highway at the edge of tree and shrub lines adjacent to open fields

FABACEAE

**Securigera varia* (L.) Lassen (Crown-vetch) Leuck 1578 (CMC 18002) September 9, 1995. First observed on the island in the mid 1980's (Wujek, personal observation), it has become more widely spread throughout the island on disturbed roadside areas.

JUGLANDACEAAE

Juglans cinerea L. (Butternut) Leuck 2002 (CMC 18242) July 24, 2010. One approximately 65+ year old tree grows on the island. The Beaver Island tree represents the most northerly Lower Peninsula record.

Juglans nigra L. (Black Walnut) Leuck & Wujek *s.n.* (CMC 18572) August 5, 2011. A Single tree planted near the end of the nineteenth century. This tree may rank among the top ten in the Michigan Big Tree List; accurate measurements are required.

LENTIBULARIACEAE

Utricularia purpurea Walter (Purple Bladderwort) Leuck 1368 (CMC 18017) September 8, 1992. Collected only from Lake Geneserath at the junction of the lake's north arm with the main body of the lake.

LYTHRACEAE

Decodon verticillatus (L.) Ell. (Whorled/Swamp Loosestrife) Wujek-Field Botany *s.n.* (CMC 11859) September 13, 1980. This species is not native to the island as the late Dr. M. Hohn transplanted three plants from Lake St. Clair in southeastern Michigan to Green's Lake in the early 1970's. These plants have since increased to over 40 individuals, but as of this date not expanded to other areas on the island.

**Lythrum salicaria* L. (Purple Loosestrife) Wujek *s.n.* (CMC 18577) Aug. 8, 2010. Many islanders know of the invasive nature of this plant; thus, as a result, as soon as a plant is observed, it is pulled or sprayed with an appropriate herbicide. Most recently observed growing along King's Highway between McCauley and Sloptown roads (Leuck, personal observation)

OROBANCHACEAE

Conopholis americana (L.) Wallr. (Squaw-root) Wujek 69 (CMC 18007) July 27, 1977. Common on the roots of mature red oaks at Green's Lake.

OXALIDACEAE

Oxalis acetosella L. (Northern Wood-sorrel, Shamrock) Wujek *s.n.* (CMC 15998) July 19, 2003. This species has been found growing in only one location, along Iron Ore Creek at the southern end of the island.

PENTHORACEAE

Penthorum sedoides L. (Ditch Stonecrop) Wujek *s.n.* (CMC 18013) July 28, 1977. Frequently growing along the shores of the Jordan River and Iron Ore Creek.

PLANTAGINACEAE

Penstemon digitalis Nutt. (Foxglove Beard-tongue) Wujek *s.n.* (CMU 15652) July 19, 2003. Only three very small populations have ever been observed on the island, the largest occurring in the field on the Grasmick's family property on McCauley Road.

Plantago rugelii Decne. (Rugel's Plantain) Wujek *s.n.* (CMC 18575) Aug. 1, 2011. Observed in disturbed areas along road and trails with the largest population on the southern side of McCauley Road.

POLYGONACEAE

**Fallopia japonica* (Houtt) Ronse Decr. (Japanese Knotweed) Leuck 2003 (CMC 18244) July 25, 2010. Two populations presently exist on the island as other populations have been destroyed.

ROSACEAE

Potentilla simplex Michx. Rousch (Common Cinquefoil) Wujek *s.n.* (CMC 17481) July 12, 1984. Common in dry open sandy forests, roadsides, and sandy barren ground.

SALICACEAE

Populus deltoides Marsh. (Cottonwood) Wujek-Field Botany 293 (CMC 18005) August 5, 1977. It grows scattered throughout the island.

Populus nigra* L. (Lombardy Popular) Wujek-Field Botany 288 (CMC 18003) August 5, 1977. It **is grown as a planting on several properties at the southern end of the island. In addition, a row grows at the corner of King's Highway and Pogenog Road.

SAPINDACEAE

Acer negundo L. (Box-elder) BC *s.n.* (CMC 18010) June 28, 1967. We found it growing in only one location in a St. James vacant lot.

**Acer platanoides* L. (Norway Maple) Leuck 2006 (CMC 18238) July 27, 2010. Planted as a shade tree throughout the town of St. James.

**Aesculus hippocastanum* L. (Horse-chestnut) K. Peschel *s.n.* (CMC 11589) July 1972. A few trees grow on the island, one at the lighthouse at the southern end of the island, and another

on Protar's property, now a museum site. Several trees have also been planted in the town of St. James.

SOLANACEAE

Solanum carolinense L. (Horse-Nettle) Wujek *s.n.* (CMC 23123) September 24, 2013. Along Hannigan Road scattered among the *Physalis heterophylla* population.

VITACEAE

Parthenocissus quinquefolia (L.) Planchon (Virginia Creeper) Basil & Berg *s.n.* (CMU 23114) August 7, 1975. Found growing at many sites in St. James.

DISCUSSION

An updated list of the previous 763 plants occurring on the Beaver Island Archipelago (722 for the island itself and 41 from the surrounding islands) can be accessed at MICHIGAN FLORA ONLINE (2011), listing the vascular flora not only of Beaver Island itself, but also of the Beaver Island Archipelago as a whole. Eight hundred twelve vascular plant species (including those in this study) representing 394 genera and 116 families have now been reported for the Beaver Island Archipelago. Forty-one of the species have been reported only from the surrounding islands. Of the 812 species, 763 are angiosperms or flowering plants (272 monocots, 491 dicots), 12 are gymnosperms, and 37 are pteridophytes (31 ferns, 16 fern allies). The percentage of exotic species among the 50 newly reported species, (20 species, representing 40%), is larger than the approximately 33% exotics in the total island flora.

Although the island is too large for a meaningful Floristic Quality Index (Herman et al. 1996) to be calculated, the native plants have an average coefficient of conservatism (C) of 5.5. This is less than the 6.5 average value reported for the entire native flora of Michigan (Herman et al. 1996). The lower value for Beaver Island is likely because 82 of the Beaver Island species have a C-value of 10, and more than half have a C-value of five or lower (599/820; 73%). On nearby Hog Island, only 33 species have a C-value of 10, and over half of the species (187/293; 63.8%) have a C-value of six or greater (Whately et al. 2005).

The exotic form of *Phragmites*, *P. australis* subsp. *australis*, has invaded several areas of the Island along the Lake Michigan shoreline and is being controlled via hand-spraying. The exotic forms on the surrounding islands of High and Hat are also being treated similarly.

Conspicuously absent from Beaver Island are many of the species that occur on the lower and upper peninsulas, particularly the more southern species including woody plants such as *Carya*, *Ceanothus*, *Quercus* (other than *Q. rubra*), *Toxicodendron vernix, Hudsonia tomentosa*, and herbaceous plants such as *Apocynum androsaemifolium*, *Viola sororia*, and *Verbena bracteata*. Even plants on the nearby Fox Islands and the counties directly east on the mainland such as *Geranium maculatum*, *Osmorhiza longistylis*, *Prenanthes alba*, and *Ribes cynosbati* are absent from Beaver Island.

The largest families reported from the Beaver Island Archipelago are Cyperaceae (89 species), Asteraceae (70 species), Poaceae (54 species) and Rosaceae (41 species). The largest genera are *Carex* (64 species), *Potamogeton* (18

species), *Juncus* (11 species), *Viola* (10 species), and two genera, *Aster* and *Equisetum*, with nine species each.

One hundred thirty-one of the island's species are considered exotic (15.8% of the flora). This is higher than the 12.4% on the nearby uninhabited Hog Island (Whately et al. 2005). The Asteraceae contains the greatest number of exotic species (21) followed by the Fabaceae (12). However, on a percentage basis of those families having four or more taxa on the archipelago, the Fabaceae have 86% (12/14) exotic taxa, followed closely by the Brassicaceae 84% (16/19), and then the Caryophyllaceae at 64% (9/14).

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A NOTE ON MUCILAGE AND HERBIVORE DAMAGE ON *BRASENIA SCHREBERI* IN A NORTHERN MICHIGAN LAKE

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ABSTRACT

Herbivory is an important part of aquatic macrophyte communities, in which the intensity of herbivory can impact the composition of macrophyte communities. The undersides of the leaves of Schreber's watershield, Brasenia schreberi, are covered with a thick, clear mucilaginous substance thought to reduce herbivory. Our study tested predictions of an earlier herbivore study by examining B. schreberi in situ and analyzing how herbivore damage correlates with the amount of mucilage found on the leaves. In September 2014, we sampled floating leaves in a small lake in Marquette County, Michigan. For each leaf sampled, we weighed the mucilage, measured the leaf, and estimated the amount of herbivore damage using Image J software. We found that the amount of herbivore damage on leaves differed significantly among the different herbivore larvae and with respect to leaves with no damage, which had the most mucilage. These results suggest that herbivores may be deterred from leaves with more mucilage and that different herbivores have different levels of tolerance to mucilage. Future studies should be conducted in which plants are grown in the laboratory, the mucilage is manipulated, and herbivore behavior in response to the amount of mucilage can be measured.

KEYWORDS: *Brasenia schreberi*, plant-insect interaction, aquatic macrophyte ecology, herbivory

INTRODUCTION

Herbivory is an important feature of aquatic macrophyte communities, where the intensity of herbivory can impact community composition with ecosystem-wide effects (Carpenter and Lodge 1986; Engelhardt and Ritchie 2001; Harms and Grodowitz 2009). For example, the golden apple snail (*Pomacea canaliculata*) invades wetlands throughout southeast Asia and removes aquatic macrophyte species, resulting in plankton blooms and increases in aquatic particulates (Carlsson et al. 2004). Herbivores can reorganize aquatic food webs, thereby altering fish communities and causing ecosystem-wide effects (Pípalová 2002; Dorn and Wojdak 2004; Miller and Crawl 2006). However, despite widespread knowledge about the impacts of herbivory on aquatic communities, little is

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known about specific plant–herbivore interactions of macrophytes and herbivores.

Brasenia schreberi J.F. Gmel. (Schreber's watershield) (Cabombaceae), is an emergent macrophyte widely distributed throughout North and Central America and eastern Asia (Elakovich and Wooten 1987). In Michigan, it is widespread in ponds and small lakes in quiet waters (Voss and Reznicek 2012). *Brasenia schreberi* is an aquatic perennial plant which produces leaves that float on the water surface. The undersides of the leaves are covered with a thick, clear mucilaginous substance secreted by trichomes. The mucilage, which is composed of polysaccharides, may be involved in defending against herbivores (McGaha 1952; Cronin et al. 1999; Dorn et al. 2001; Thompson et al. 2014). It is thought that this mucilage reduces the ability of insects to feed by interfering with their mouthparts or by inhibiting access to photosynthetic tissue thereby causing an obstruction to feeding (Thompson et al. 2014).

Twelve different species of insects have been identified as feeding on *B. schreberi* (Harms and Grodowitz 2009). These insects are representative of four families in three different orders: Chrysomelidae and Curculionidae (both Coleoptera), Chrionomidae (Diptera), and Pyralidae (Lepidoptera). Species in these families feed on a wide variety of aquatic macrophytes, and several members of Chrysomelidae, particularly *Donacia* spp., target macrophytes with floating leaves. These herbivores all have varied life histories and feeding habits that result in distinctly different feeding damage by each on host plants.

Although many insect species consume *B. schreberi*, the mucilage has only recently been shown to reduce insect herbivore feeding in general (Thompson et al. 2014). In a series of experiments, Thompson et al. (2014) scraped mucilage off individual *B. schreberi* leaves and recorded an increase of herbivore damage, showing that mucilage likely deters herbivores.

The objective of this study was to test the predictions of Thompson et al. (2014) as well as to look at *B. schreberi* damage *in situ* and analyze how this damage correlates with the amount of mucilage found on leaves (assuming that not all leaves have the same amount of mucilage).

MATERIALS AND METHODS

Leaves of *B. schreberi* were sampled at Harlow Lake, a property of the Michigan Department of Natural Resources, in Marquette County, Michigan in early September 2014 (Figure 1). In Harlow Lake, *B. schreberi* has a patchy distribution and is typically found within 30 m of the shoreline. We selected three patches of *B. schreberi* and, in each patch, sampled along one 20 m transect perpendicular to the shoreline. Using the point center quarter method, we sampled a total of 228 floating leaves. We selected leaves that showed signs of herbivory and leaves that did not show signs of herbivory. Leaves with no herbivory were selected so that we could compare the amount of mucilage on those leaves to leaves with herbivory. Leaves were cut from the stem and stored in a labeled bag. Samples were brought back to the laboratory immediately after sampling.

Sampled leaves were patted dry and photographed on a brightly colored background with a Sony Cybershot camera (14.1 megapixels). Areas of the background that showed through the leaves were considered areas of herbivore damage (Thompson et al. 2014). Mucilage was then removed from leaves using a razor blade and immediately weighed. The leaf images were manually edited using Adobe Photoshop Elements 9 to enhance the contrast between undamaged and herbivore damaged areas of the leaf (Figure 2). The public domain software Image J (Version 1.48) was used on these photographs to estimate the total leaf area and the percentage of the total area that was damaged by

FIGURE 1. Sampling at Harlow Lake, Marquette Co., Michigan. Leaves of *Brasenia schreberi* are visible around the canoe and dominate the submerged zone. Photo by Kevin Heynig.

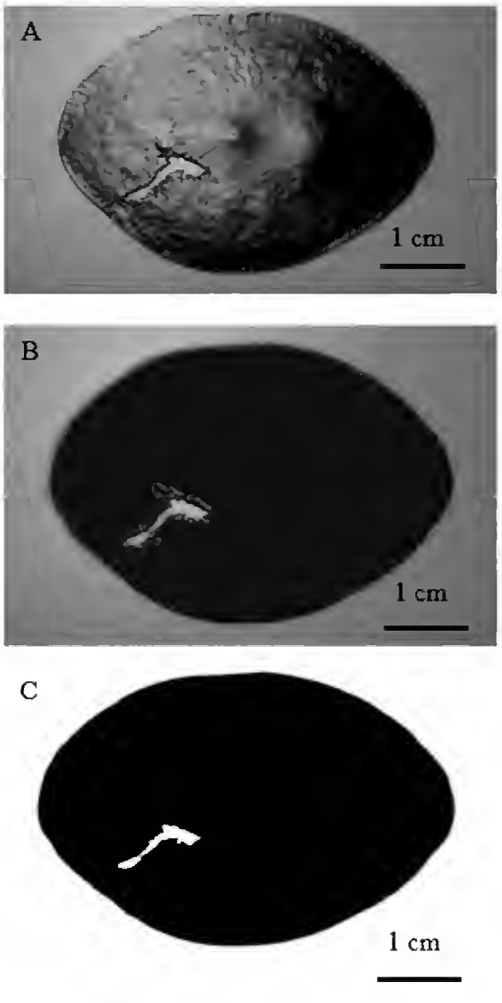

FIGURE 2. Representation of editing watershield photos to better estimate herbivore damage. (A) raw photo of watershield; (B) enhanced contrast between undamaged areas and herbivore damaged areas in Adobe Photoshop; (C) end result of photo in Image J. The increased contrast permits a better estimation of leaf area and herbivore damage measurements.

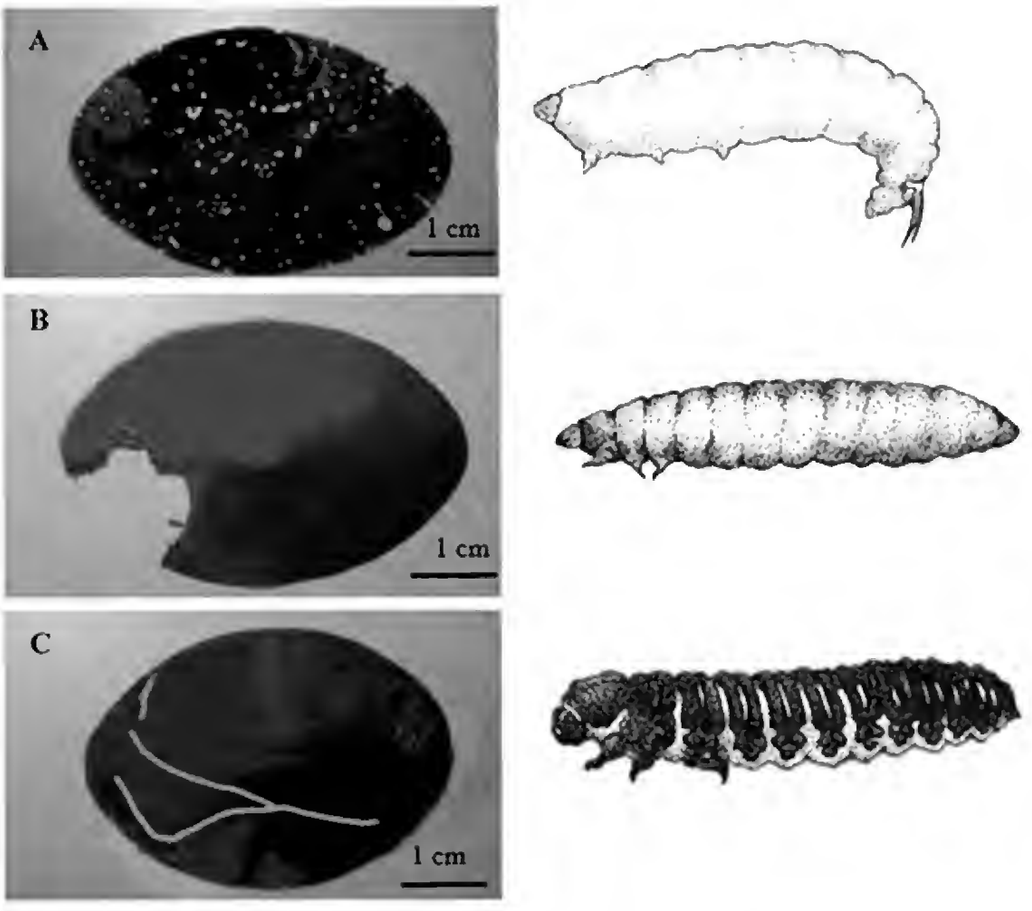

FIGURE 3. Common herbivores of *Brasenia schreberi* and examples of damage caused to leaves by each. A) The leaf beetle (*Donacia* spp.) (Coleoptera: Chrysomelidae) creates small random bite marks; B) the aquatic moth (Lepidoptera: Pyralidae) cuts out large contiguous areas for leaf shelters; and C) the waterlily leaf beetle (*Galerucella nymphaeae*) (Coleoptera: Chrysomelidae) leaves long linear mines through the leaf surface. Larvae illustrations by Jen Koppin.

herbivores. Areas of herbivore damage were visually assessed, and the pattern of damage was assigned to a specific herbivore based on previous research and known feeding habits of each of the herbivores (Merritt et al. 2008, Thompson et al. 2014). Although there is some overlap in the feeding habits of the different herbivores on the leaves and therefore a slight amount of pseudoreplication, we believe that the insects responded differently enough that this did not bias our results (Oksanen 2001). In our leaf samples, we detected herbivore damage representative of three types of aquatic larvae. These were aquatic moths (Lepidoptera: Pyralidae) and two beetles, the waterlily leaf beetle (*Galerucella nymphaeae*) and the leaf beetle (*Donacia* spp.) (both Coleoptera: Chrysomelidae) (Figure 3). We used a one-way ANOVA to test for differences in herbivore damage on leaves, and a Tukey's Multiple Comparisons test for pairwise comparisons among herbivores in R (3.3.2).

RESULTS

The amount of herbivore damage on leaves differed significantly among the herbivore larvae and with respect to leaves with no herbivore damage (ANOVA: $F_{1,\ 196} = 13.84$, $p=0.038$). Tukey HSD post-hoc analysis showed that herbivore damage to leaves by the aquatic moth larvae differed significantly from the her-

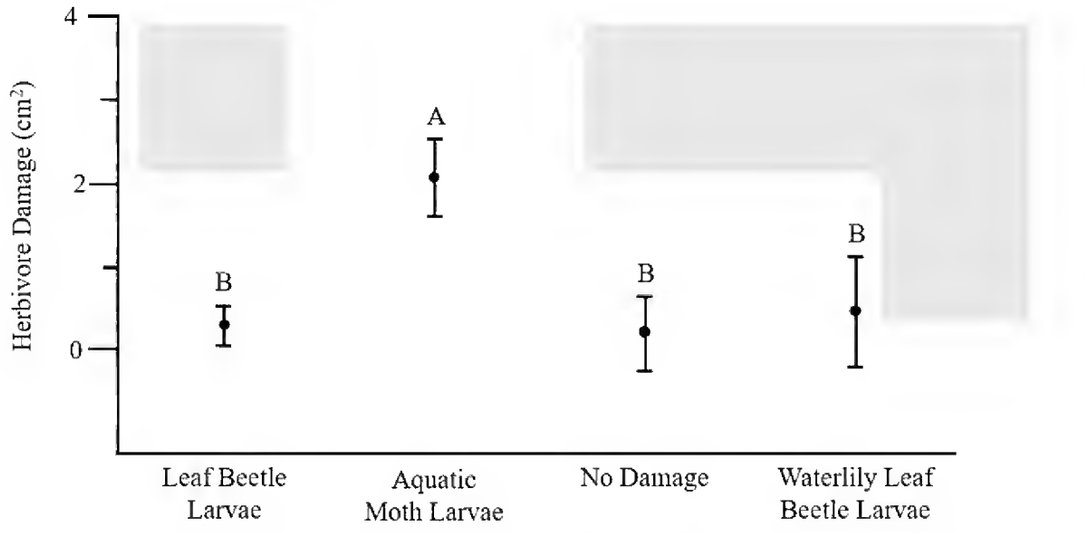

FIGURE 4. Results of one-way ANOVA and of Tukey's Multiple Comparisons test for pairwise comparisons among herbivore damage by the leaf beetle, the aquatic moth, and the waterlily leaf beetle larva, and leaves with no damage. Leaves with damage by the aquatic moth larvae differed significantly from leaves with damage from the other herbivore larvae and from leaves with no damage ($p < 0.05$). Different letters indicate significant differences between herbivores.

bivore damage to leaves by other larvae and from leaves with no herbivore damage ($p < 0.05$, Figure 4). In addition, leaves with no herbivore damage (0.0 cm^2) had the greatest amount of mucilage (0.76 ± 0.5 g), and leaves with high amounts of damage (2.03 ± 3.20 cm^2) had lesser amounts of mucilage (0.46 ± 0.41 g). Leaves with a moderate amount of mucilage were exposed to the greatest herbivore damage by the aquatic moth larvae, whereas leaves with the least amount of mucilage had the most herbivore damage to leaves by the two beetle larvae (Table 1).

DISCUSSION

The results indicate that aquatic moth larvae are able to tolerate greater amounts of mucilage than the leaf beetle larvae or the waterlily leaf beetle larvae. Beetles chew through the whole leaf, thereby being exposed to mucilage in almost all of their feeding. In contrast, adult aquatic moths lay their eggs on the

TABLE 1. Average leaf area, average herbivore damage, and average mucilage weight, with standard deviations of each, for leaves with herbivore damage on *Brasenia schreberi* by each of the three larval herbivores—aquatic moth larva, waterlily leaf beetle larva, and leaf beetle larva.

Herbivore Type	Avg. Leaf Area (cm^2)	Avg. Herbivore Damage (cm^2)	Avg. Mucilage Weight (g)
Aquatic Moth	38.2 ± 13.6	2.03 ± 3.20	0.46 ± 0.41
Waterlily Leaf Beetle	47.9 ± 15.4	0.57 ± 0.46	0.19 ± 0.18
Leaf Beetle	43.4 ± 13.8	0.35 ± 0.43	0.32 ± 0.36
No Damage	37.5 ± 13.2	0.00	0.76 ± 0.50

top of emergent shoots where there is little mucilage (Merritt et al. 2008). The moth larvae then hatch and chew the leaves from the top and "flip" the leaf over themselves as a shelter, thus avoiding areas with the most mucilage. These moth larvae then feed inside, eating parts of the leaves free of any mucilage.

Herbivory on *B. schreberi* is varied, and undoubtedly damage by other herbivores or by other factors could not be accounted for by our sampling. Even if herbivores such as moose or muskrats were influenced by mucilage, their feeding would completely remove plants and we would have missed their impacts. It is also possible that mucilage plays a role in allelopathy and competition among other aquatic macrophytes in addition to its role as a defense against herbivory (Elakovitch and Wooten 1987).

Environmental variables such as water depth or distance from the population to shore could also influence the macrophyte community and the herbivores present in the study area. Aquatic herbivores can be influenced by water depths and may therefore be absent from areas of greater depths (Aroviita and Hamalainen 2008). Turbidity and water chemistry also impact plant growth, and this can in turn impact the production of defense traits with ripple effects on insect herbivory.

In order to further examine the role that mucilage plays in the ecosystem, manipulative studies should be pursued. Studies in which *B. schreberi* is grown in the laboratory and exposed to herbivores would facilitate the direct observation of insect behavior. Studies throughout the extensive intra-continental range of *B. schreberi* would allow comparative tests of selection pressures on variation in the amount of mucilage on leaves. *Brasenia schreberi* and its associated insect herbivores provide an interesting system for many disciplines studying ecosystem interactions in aquatic food webs.

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THE VASCULAR FLORA OF LUDINGTON STATE PARK, MASON COUNTY, MICHIGAN

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ABSTRACT

The vascular flora of Ludington State Park, Mason County, Michigan was inventoried and additional historical taxa was noted. Ludington State Park borders Lake Michigan along the western boundary of Mason County and lies wholly within Hamlin Township. A total of 444 taxa of vascular plants in 101 families and 281 genera are now documented for Ludington State Park, including 102 non-native taxa, which constitute 23 percent of the total. The Park includes a diversity of natural communities, including Open Dunes, Great Lakes Barrens, Dry-Mesic Northern Forest, and three types of Palustrine Wetlands. Typical taxa associated with each plant community are described. During the course of this study, 112 taxa were collected that are new to Mason County, including *Corispermum pallasii* (a Michigan Special Concern species). Several taxa that are at or near the limits of their known ranges in the Park include *Andropogon virginicus*, *Bidens discoidea*, *Boechera laevigata*, and *Goodyera oblongifolia*.

KEYWORDS: Flora of Ludington State Park, Michigan, Vascular Plants, Open Dunes, Interdunal Wetlands, Great Lakes Barrens.

INTRODUCTION

Ludington State Park (the Park) borders Lake Michigan along the western boundary of Mason County, Michigan (Figure 1). The Park was established in 1936 and currently includes 5,300 acres of land (Michigan Department of Natural Resources 2016), which lies wholly within Hamlin Township (T19N, R18W) approximately 2.5 miles north of the City of Ludington and immediately south of Nordhouse Dunes Wilderness Area (NDWA) within Manistee National Forest. The Park includes the vast majority of acreage between Hamlin Lake and Lake Michigan, and extends six linear miles from north to south.

Geological and Glacial History

The Park is located within the Manistee Subsection (Subsection VII.4) of the Northern Lacustrine-Influenced Lower Michigan Section (Section VII) of the regional landscape ecosystem classification system for Michigan, Minnesota, and Wisconsin as described by Albert (1995). This subsection is characterized by sandy lake plain and sand end moraine ridges, with very extensive areas of parabolic and perched dune along the shoreline of Lake Michigan (Higman et al. 2002).

Landscape features in Mason County were formed by the complex action of the Lake Michigan lobe of the Wisconsin glacial ice sheet. Winds modified some

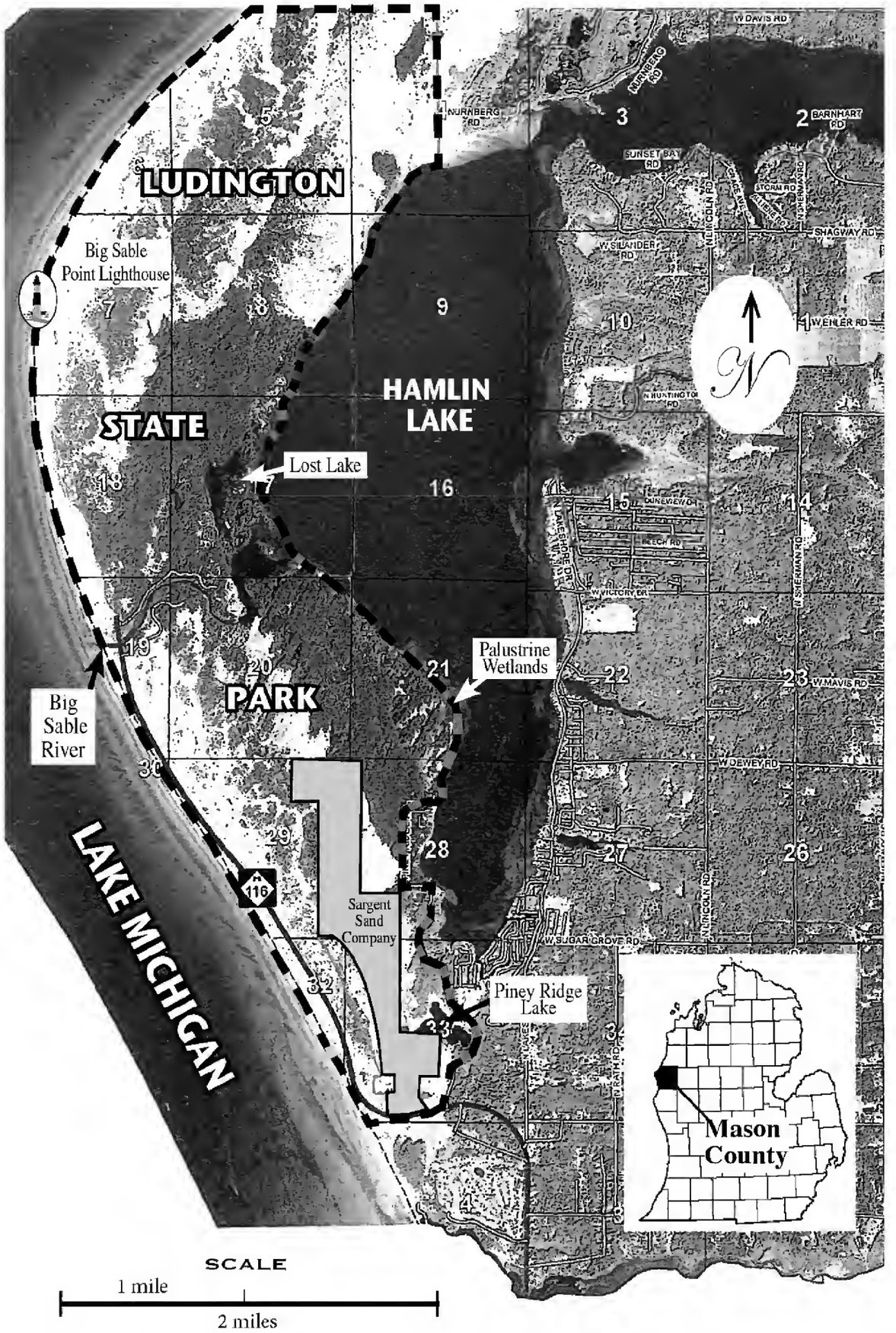

FIGURE 1. Ludington State Park, Mason County, Michigan. Aerial photo base reproduced with the permission of Mapping Solutions; 816-903-3500; mappingsolutionsgis.com

of the land features and deposited large dunes along most of the coast of Lake Michigan (USDA, NRCS, FS 1995). Surface sediments across the Park consist of dune sand. The thickness of glacial drift in the Park varies between 600 and 800 feet. The glacial drift is underlain by the Late Devonian Ellsworth Shale. Currently, the majority of the Park, including all major sand dune areas, is designated as Critical Dunes by the Department of Environmental Quality (DEQ) (MDNR, P&RD 2016).

Climate

Mason County lies within the Laurentian Mixed Forest Province, which is a transitional zone between the boreal forest and broadleaf deciduous forest characterized by warm summers and cold winters as described for ecoregions of the United States by the USDA (Bailey 1995), though the location of the Park along the east edge of Lake Michigan greatly moderates temperature extremes. This lake-modified climate results in a long growing season of 140 to 150 days. The annual precipitation averages 33 inches per year, and the average range of annual snowfall is 100 to 140 inches (Michigan Department of Natural Resources 2016). Furthermore, Mason County occurs a couple counties north of the center of the transition zone or "tension zone" between the Northern Hardwood Forest and the Boreal Forest (Barnes and Wagner 1981, Figure 18; and Andersen 2005, Figure 1). The climatic tension zone and areas along the Great Lakes shoreline with lake-moderated climate, often support species with both northern and southern affinities (Andersen 2005; and Cohen et al. 2015). Additionally, according to the USDA Plant Hardiness Zones map for Michigan, Mason County's coastal areas occur within Zone 6a, which has an average annual minimum temperature of –10°F to –5°F (USDA 2017).

Soils

The soils in the Park are of two primary types: Dune land—Quartzipsamments complex and Nordhouse fine sand. In general, soils in the western half of the Park are of the former soil type, and soils in the eastern half of the Park are of the latter soil type (MDNR, P&RD, 2016). Because these soils are overwhelmingly sand-dominated, even in forested areas, they are considered excessively drained, have rapid permeability, and are highly susceptible to erosion (USDA, NRCS, FS 1995). Consequently, plant life in these soils is adaptable to xeric conditions. Even within the forested dunes, there is only several inches of topsoil, which may be a result both of the relatively young age of the forested dune (relative to less dynamic inland forests) and of impacts from the logging era in the 1800s. On the other hand, wetland (hydric) soils that occur in interdunal wetlands and palustrine wetlands bordering Hamlin Lake, have accumulated layers of clay and organic matter over time due to high water levels, which results in low oxygen levels, thereby decreasing the rate of decomposition. Consequently, these soils support wetland vegetation.

MATERIALS AND METHODS

Floristic Inventory

Annual surveys of vascular plants at the Park were conducted on foot by the author beginning in 2009 and concluding in 2014 (subsequent to the survey period, two non-native taxa were collected in 2016: *Verbena bracteata* and *Berberis vulgaris*; which are included in Appendix 1). Shallow water wetlands (to a maximum of approximately three feet in depth) were surveyed on foot without the use of a boat. A total of 101 field days and 354 field hours from April through October were undertaken during the six years of surveys, the earliest field day being April 1 and the latest October 14. Surveys followed existing trails and roads throughout the Park, but also included random meandering in specific habitats in the efforts to maximize the diversity of taxa encountered. Voucher specimens were collected for every taxon encountered, except that native species that were represented by only a few plants were not collected, but instead were photographed, and collection of state and federal listed species was not permitted. Plants were collected in flowering or fruiting condition if possible, and the lack of such conditions excluded some taxa from collecting (e.g, *Aralia nudicaulis* and *Chimaphila umbellata*). Several other taxa were found in vegetative conditions but were only identifiable to genus (*e.g.*, *Apocynum* sp., *Cypripedium* sp., *Erythronium* sp., and *Prenanthes* sp.), and thus were not collected. Herbarium specimens were deposited at the University of Michigan Herbarium (MICH), and identifications were verified by Anton A. Reznicek, curator at MICH.

The presence and quality of natural plant communities in the Park is addressed below in Results by an analysis of the 444 taxa (including subspecies) listed during the survey period, including 15 strictly historical taxa. This includes a FQA analysis, a review of regionally rare taxa, and summary of taxa new to Mason County. Also, six natural communities as defined by the Michigan Natural Features Inventory (Cohen et al. 2015) are also described below under Results.

Previous Collecting in the Park

The author requested information from MICH regarding collections that predated those of the author in the Park. Previous botanical surveys in the Park date back to 1934 when Frank C. Gates collected *Carex garberi* (#17677) "at Hamlin Lake, Michigan State Park" (Mason County list provided by Beverly Walters, MICH, on December 18, 2014). Very little plant collecting within the Park occurred thereafter until the late 1940s and early 1950s. A list of 11 collectors who collected a total of 83 specimens in the Park prior to the current study is provided in Table 1. However, the list also included numerous dubious locations, such as "Hamlin Lake" or "Near Ludington" that did not specify whether they were from the modern-day Park. And while no formal survey of the vascular flora had been conducted previously, a natural features inventory was conducted in 1995 and 1996 (Higman et al. 2002). The inventory found that the state and federal Threatened *Cirsium pitcheri* remains common in open dunes, whereas the state Threatened *Orobanche fasciculata* (last observed in 1985) and the state Special Concern *Cypripedium arietinum* (last observed in 2007) were not re-located.

TABLE 1. Summary of Ludington State Park collectors prior to 2009 with vouchers at MICH (50), WUD (29), MSC (7), BLH (3), and UMBS (1).

Collector	Collecting Year (s)	Number of Vouchers
Frank C. Gates	1934	1
Harley H. Bartlett	1937	13
Rogers McVaugh	1949, 1951	9
N. W. Katz	1951	3
Dale A. Zimmerman	1952	8
C. Marvin Rogers	1953	29
Florence V. Hoseney	1973	1
Sue Lillie	1975	1
Timothy S. Mustard	1979	1
Michael R. Penskar	1986	1
Scott Herron	1998, 1999, 2000	16
TOTALS	13	83

Floristic Quality Assessment

Much of Michigan's native biota is now restricted to relatively small and often isolated tracts of landscape across the state. Floristic Quality Assessment (FQA) is a tool for assessing the floristic, and, implicitly, the natural significance of any given area (Herman et al. 2001). The concept of species conservatism is the foundation of floristic quality assessment. Each native Michigan species has a **coefficient of conservatism** (*C*) following the methodology and philosophy detailed in Herman et al. (2001). Coefficients of conservatism range from 0 to 10 for native species and represent an estimated probability that a plant is likely to occur in a landscape relatively unaltered from what is believed to be pre-European settlement condition. A *C* of 0, for example, is given to plants such as *Ambrosia artemisiifolia* (common ragweed) that demonstrate little fidelity to any remnant natural community, that is, it may be found almost anywhere, whereas a *C* of 10 is given to plants such as *Conopholis americana* (squaw-root) that are almost always restricted to a presettlement remnant, that is, a high quality natural area. Non-native and exotic species are not included in FQA calculations. Floristic Quality Assessment is applied by calculating a **mean coefficient of conservatism** ($\bar{C}$) and a **floristic quality index** (*FQI*) from a comprehensive list of plant species obtained from a particular site, in this case the Park. This is done by summing the coefficients of conservatism (*C*) of an inventory of plants and dividing by the total number of native plant taxa (*n*), yielding an average or the

TABLE 2. Taxa with Coefficient of Conservatism (*C*) ranking of 9 or 10 in Ludington State Park. C rankings are taken from individual species listings in MICHIGAN FLORA ONLINE (2011).

Scientific Name	Common Name	(*C*)
Ammophila breviligulata	Beach Grass	10
Anticlea elegans	White Camas	10
Bidens beckii	Water-Marigold	10
Calamagrostis stricta	Narrow-leaved Reedgrass	10
Calamovilfa longifolia	Sand Reed Grass	10
Calla palustris	Wild Calla	10
Carex alata	Winged Sedge	10
Carex buxbaumii	Buxbaum's Sedge	10
Carex disperma	Softleaf Sedge	10
Carex folliculata	Northern Long Sedge	10
Cirsium pitcheri	Pitcher's Thistle	10
Cladium mariscoides	Twig-Rush	10
Conopholis americana	Squaw-Root	10
Cypripedium arietinum	Ram's Head Lady Slipper	10
Eleocharis quinqueflora	Few-Flowered Spike-Rush	10
Eipfagus virginiana	Beech-Drops	10
Euphorbia polygonifolia	Seaside Spurge	10
Hudsonia tomentosa	Beach-Heath	10
Hypericum kalmianum	Kalm's St. John's-Wort	10
Lathyrus japonicus	Beach Pea	10
Linum striatum	Stiff Yellow Flax	10
Lithospermum caroliniense	Hairy Puccoon	10
Lobelia kalmii	Kalm's Lobelia	10
Orobanche fasciculata	Clustered Broom Rape	10
Pedicularis canadensis	Wood-Betony	10
Rhynchospora capillacea	Needle Beak-Rush	10
Salix cordata	Sand-Dune Willow	10
Solidago simplex	Gilman's Goldenrod	10
Utricularia cornuta	Horned Bladderwort	10
Utricularia intermedia	Flat-Leaved Bladderwort	10
Eriocaulon aquaticum	Sevenangle Pipewort	9
Koeleria macrantha	June Grass	9
Rumex orbiculatus	Great Water Dock	9
Salix myricoides	Blueleaf Willow	9

mean coefficient of conservatism ($\bar{C} = \sum C / n$). The $\bar{C}$ is then multiplied by the square root of the total number of native taxa ($\sqrt{n}$) to yield the floristic quality index ($FQI = \bar{C}\sqrt{n}$) (Herman et al. 2001). All taxa collected within the Park were noted with their coefficient of conservatism, which is presented in the Appendix. Additionally, taxa that ranked a 9 or 10 coefficient of conservatism are listed separately in Table 2. Final calculations of $\bar{C}$ and *FQI* are presented below under Results.

RESULTS

A total of 444 taxa (including subspecies) of vascular plants, representing 101 families and 281 genera, were documented for the Park, as shown in Table 3 and Appendix 1. Fifteen of these taxa are strictly historical and were documented by the following collectors: Bartlett (3 taxa), Herron (2), Hoseney (1), Katz (1), McVaugh (4), and Rogers (4). Of all taxa, 342 (77 percent) are considered native and 102 (23 percent) are exotics (Herman, et al., 2001). The 444 taxa can further be broken into major plant groups as follows: Pteridophytes (19), Gymnosperms (5), Monocots (138), and Dicots (282) as shown in Table 3. Families represented by the greatest number of taxa are Poaceae (52), Asteraceae (44), and Cyperaceae (43) as shown in Table 4. Twenty-seven of the taxa in the Cyperaceae are in the genus *Carex*, reflecting good diversity in various wetlands within the Park. The complete list includes state and federal listed taxa, and several that are regionally rare (see Listed and Regionally Rare Taxa below). Also, four rare taxa are documented only by photo vouchers: *Aralia nudicaulis*, *Chimaphila umbellata*, *Lobelia cardinalis*, and *Menyanthes trifoliata* (the latter two photographed prior to the study). These are included in Appendix 1.

TABLE 3. Number of families, genera, and taxa (including subspecies) for each of the major groups of plants in Ludington State Park.

Group	Families	Genera	Taxa
Pteridophytes	11	13	19
Gymnosperms	2	4	5
Monocots	16	69	138
Dicots	72	195	282
TOTALS	101	281	444

TABLE 4. The total number of taxa and the number of non-native taxa in each of the ten largest families in Ludington State Park.

Family	Total Number of Taxa	Non-Native Taxa (percentage of total)
Poaceae	52	17 (33%)
Asteraceae	44	14 (32%)
Cyperaceae	43	0 (0%)
Rosaceae	19	1 (5%)
Brassicaceae	15	9 (60%)
Ericaceae	13	0 (0%)
Lamiaceae	12	4 (33%)
Fabaceae	11	9 (82%)
Polygonaceae	9	3 (33%)
Caryophyllaceae	9	8 (89%)
TOTALS	227	65 (29%)

TABLE 5. Excluded taxa represented by vouchers.

Scientific Name	Common Name	Voucher ID	Comments
Acer saccharinum	Silver Maple	Dister 246	No regeneration; likely planted
Alnus glutinosa	Black Alder	Dister 385	No regeneration; likely planted
Cornus foemina or	Gray Dogwood or	Dister 289	No regeneration; likely planted
Cornus × *rugosa*	Dogwood Hybrid	Dister 331	[same plant as Dister 289]
Erigeron annuus	Annual Fleabane	Dister 194	Uncertain identification
Juglans nigra	Black Walnut	Dister 146	No regeneration; likely planted
Pinus resinosa	Red Pine	Dister 282	No regeneration; likely planted
Pinus sylvestris	Scotch Pine	Dister 361	No regeneration; likely planted
Populus balsamifera	Balsam Poplar	Dister 332	No regeneration; likely planted
Populus nigra	Lombardy Poplar	Dister 494	Some root sprouts; likely planted
Rosa multiflora	Multiflora Rose	Dister 323	No regeneration; likely planted
Rosa rubiginosa	Sweetbrier	Dister 398	Some root sprouts; likely planted
Rosa setigera	Prairie Rose	Dister 205	No regeneration; likely planted
Ulmus ?	Elm Hybrid ?	Dister 351	Possible hybrid
Yucca flaccida	Weak-leaf Yucca	Dister 156	No regeneration; likely planted

Fifteen taxa with vouchers that were excluded for various reasons are presented in Table 5. Most such excluded taxa were likely planted and lacked regeneration, or vouchers could not be definitely identified to species or subspecies level. About half of these taxa are non-native species commonly available in the nursery trade, while some of the natives occur along roadsides (*e.g.*, *Juglans nigra* and *Populus balsamifera*) or riverbanks (*e.g*, three plants of *Cornus foemina* in a triangular formation).

Species richness as determined by higher taxa diversity occurs within the emergent and submergent wetlands within the Park, typically in the interdunal wetlands throughout the Park and deepwater wetlands along the eastern edge of the Park bordering Hamlin Lake (i.e., in the vicinity of the Canoe Trail). Invasive plants, however, are widespread, particularly *Centaurea stoebe*, *Berberis thunbergii*, *Cynoglossum officinale*, *and Phragmites australis* subsp. *australis*. Fortunately, there has been significant effort to control *Phragmites australis* subsp. *australis* and *Berberis thunbergii*.

In addition to vouchered taxa, there are four taxa lacking vouchers that are also excluded. These taxa lacked regeneration and were likely or obviously planted (Table 6). None of these species is native to Michigan, and all are (or have been) widely available in the nursery trade.

A determination of the $\bar{C}$ for the Park resulted in a score of 4.9, which compares with 5.1 determined by the author for the NDWA study by Hazlett (1986a, 1986b). Additionally, a determination of the *FQI* for the Park resulted in a score

TABLE 6. Excluded taxa not represented by vouchers. All are planted non-natives.

Scientific Name	Common Name	Comments
Ligustrum sp.	Privet sp.	No regeneration; likely planted
Picea abies	Norway Spruce	No regeneration; obviously planted
Picea pungens	Blue Spruce	No regeneration; obviously planted
Robinia pseudoacacia	Black Locust	No regeneration; likely planted

of 91.1, which compares with 91.5 determined by the author for the NDWA study (Hazlett 1986a, 1986b). The slightly higher score of $\bar{C}$ and FQI for NDWA may be a reflection of its "Wilderness" designation that implies a more intact ecosystem than that at the Park. Also, 23 percent (102) of the vouchered taxa at the Park are considered non-native, whereas only 12 percent (43) are considered non-native at NDWA based on the Hazlett study conducted three decades earlier.

State and Federally Listed Taxa and Regionally Rare Taxa

The Michigan Natural Features Inventory (MNFI) tracks plants that are protected at the state level under the categories Endangered (E), Threatened (T), and Probably Extirpated (referred to as "listed" species). In addition, the MNFI notes species of Special Concern (SC), which, although not legally protected, are of concern because of their small or declining population sizes. Four species known from the Park are listed or treated as Special Concern by the State of Michigan. These are *Cirsium pitcheri* (Figure 2) (T), *Orobanche fasciculata* (Figure 3) (T), *Cypripedium arietinum* (Figure 4) (SC), and *Corispermum pallasii* (Figure 5) (SC). Although *Cirsium pitcheri*, (which also has a federal Threatened status), remains common within open dune habitat in the Park, neither *Orobanche fasciculata* nor *Cypripedium arietinum* were located during repeated surveys from

FIGURE 2. *Cirsium pitcheri*. June 21, 2009. Photo by David C. Dister.

FIGURE 3. *Orobanche fasciculata*. No date. Photo provided by Jim Gallie, park manager at Ludington State Park. Used with permission.

2009 through 2014. *Orobanche fasciculata* has not been observed since 1985 (Higman et al. 2002), but *Cypripedium arietinum* was observed and its locations noted by Bob Sanders and Cyrus Hester in the summer of 2007 (Sanders, pers. comm.). A follow-up visit to these locations on June 9, 2016 by the author failed to find this rare orchid. *Corispermum pallasii* was not previously known in the Park.

Regionally rare taxa discovered during the current surveys include *Chimaphila maculata*, *Eriocaulon aquaticum* (Figure 6), *Goodyera oblongifolia* (at the southernmost station in Michigan; Figure 7) *Triglochin maritima* (Figure 8), *Andropogon virginicus* (at the northern edge of its known range in Michigan), *Carex atlantica* (near the northern limit of its known range), *Carex peckii* (near the southern limit of its known range), *Patis racemosa*, *Bidens discoidea* (at the northern edge of its known range in the lower peninsula of Michigan), *Boechera laevigata* (a new northernmost station in the state), and *Parietaria pensylvanica* (one of the more northern known stations in the state). The Park location for *Sicyos angulatus*, which was collected in 1973, but was not relocated during the present study, represents the northernmost known station of this species in the state.

New Records

There were 112 taxa that represented new records for Mason County as a result of this study at the Park. These new records were determined by review of a list of Mason County vouchers at MICH marked for Ludington State Park (provided by Beverly Walters on December 18, 2014). This accounts for 25 percent of the Park's documented vascular flora to date. Only one of the new county records is state-listed: bugseed (*Corispermum pallasii)*, a Michigan Special Concern species. This and several regionally rare taxa are further addressed under Discussion.

FIGURE 4. *Cypripedium arietinum*. Summer 2007. Photo by Cyrus Hester. Used with permission.

FIGURE 5. *Corispermum pallasii*. Fruit depicted. September 11, 2011. Photo by David C. Dister.

Natural Plant Communities

Ludington State Park contained some of the largest areas of unvegetated open dunes encountered by the General Land Office surveyors in the early 1800s. The greater part of the area that is included in the Park was described by the surveyors in 1835 as "loose sand hills" and "no trees." Today, much of the Park remains similar to the conditions described by the General Land Office surveyors (Higman et al. 2002).

The Park consists of six natural communities as classified by the Michigan Natural Features Inventory (Cohen et al. 2015). The classification of natural communities consists of five Classes, each of which are further subdivided into one or more Groups, and then into specific Natural Communities. The six natural communities represented in the Park are: submergent marsh, emergent marsh, interdunal wetland, dry-mesic northern forest, open dunes, and Great Lakes barrens. Of these natural communities, the most important from a regional and statewide perspective are the Great Lakes barrens, open dunes, and interdunal wetlands. Ludington State Park includes some of the highest quality and

FIGURE 6. *Eriocaulon aquaticum*. July 15, 2012. Photo by David C. Dister.

FIGURE 7. *Goodyera oblongifolia*. Leaves depicted. May 31, 2009. Photo by David C. Dister.

FIGURE 8. *Triglochin maritima*. July 5, 2009. Photo by David C. Dister.

largest examples of these three communities in the Great Lakes region (MDNR, P&RD, 2016). Descriptions of these natural communities follows.

Palustrine Class – Marsh Group

Submergent Marsh

Submergent marsh is an herbaceous plant community that occurs in deep to sometimes shallow water in lakes and streams in Michigan. . . . Vegetation is comprised of both rooted and non-rooted plants that occur completely beneath the water surface (i.e., submergent plants), rooted floating-leaved plants, and non-rooted floating-leaved plants. (Cohen et al. 2015).

This plant community occurs along the eastern boundary of the Park bordering Hamlin Lake in Sections 8, 17 (Lost Lake vicinity), 21, and 28 (north to south) (Figures 1 and 9). Characteristic species found in this community within the Park include: *Elodea canadensis*, *Valisneria americana*, *Myriophyllum verticillatum*, *Heteranthera dubia*, *Potamogeton friesii*, *Potamogeton gramineus*, *Potamogeton zosteriformis*, *Stuckenia pectinata*, *Brasenia schreberi*, *Nuphar variegata*, *Nymphaea odorata*, *Lemna trisulca*, *Lemna turionifera*, and *Spirodela polyrhiza*.

Emergent Marsh

Emergent marsh is a shallow water wetland that occurs along the shores of lakes and streams throughout Michigan. Water depth of 15 cm (6 in) or more is usually present throughout the growing season. . . . Vegetation is comprised of

FIGURE 9. Submergent Marsh. July 15, 2016. Photo by David C. Dister.

narrow- and broad-leaved graminoids (i.e., grass-like plants) and herbs that extend above the water surface (i.e., emergent plants), as well as floating-leaved plants. (Cohen et al. 2015).

This plant community also occurs along the eastern boundary of the Park bordering Hamlin Lake as described for the submergent marsh community above (Figures 1 and 10). Characteristic species found in this community within the Park include: *Carex aquatilis*, *Carex lacustris*, *Carex lasiocarpa*, *Dulichium arundinaceum*, *Leersia oryzoides*, *Zizania palustris*, *Pontedaria cordata*, *Sagittaria latifolia*, *Sparganium natans*, *Thelypteris palustris*, *Brasenia schreberi*, *Nuphar variegata*, *Nymphaea odorata*, *Lemna trisulca*, *Lemna turionifera*, and *Spirodela polyrhiza*.

Interdunal Wetland

Interdunal wetland is a rush-, sedge-, and shrub-dominated wetland situated in depressions within open dunes or between beach ridges along the shorelines of the Great Lakes. . . . Water levels fluctuate both seasonally and from year to year in synchrony with changes in the Great Lakes water levels and strongly influence species composition and community structure. (Cohen et al. 2015).

This plant community occurs between the foredunes bordering Lake Michigan and the higher forested dunes further inland (Figures 1 and 11). Characteristic species found in this community within the Park include: *Calamagrostis canadensis*, *Carex garberi*, *Carex viridula*, *Cladium mariscoides*, *Eleocharis elliptica*, *Eleocharis quinqueflora*, *Juncus balticus*, *Schoenoplectus pungens*, *Triglochin maritima*, *Utricularia cornuta*, and *Hypericum kalmianum*.

FIGURE 10. Emergent Marsh. July 17, 2016. Photo by David C. Dister.

FIGURE 11. Interdunal Wetland. June 8, 2013. Photo by David C. Dister.

Terrestrial Class – Forest Group

Dry-mesic Northern Forest

Dry-mesic northern forest is a pine or pine-hardwood forest found throughout the Upper Peninsula and northern Lower Peninsula . . . . Dry-mesic northern forest develops on extremely to very strongly acidic sands or loamy sands. (Cohen et al. 2015).

This plant community occurs on the inland high dunes, ridges, and valleys within the east-central portion of the Park (Figures 1 and 12). Characteristic species found in this community within the Park include: *Avenella flexuosa*, *Carex pensylvanica*, *Oryzopsis asperifolia*, *Maianthemum canadense*, *Mitchella repens*, *Polygala paucifolia*, *Trientalis borealis*, *Dryopteris intermedia*, *Pteridium aquilinum*, *Gaultheria procumbens*, *Gaylussacia baccacta*, *Vaccinium angustifolium*, *Acer rubrum*, *Pinus strobus*, *Quercus rubra*, and *Tsuga canadensis*.

Primary Class – Dunes Group

Open Dunes

Open dunes is a grass- and shrub-dominated community located on wind-deposited sand formations near the shorelines of the Great Lakes. . . . Blowouts, sand burial and abrasion, excessively well-drained and droughty soils, desiccating winds, and occasional fires maintain open conditions. (Cohen et al. 2015).

This plant community is interspersed with Great Lakes Barrens and dominates the northern third and the southern third of the Park (Figures 1 and 13). Characteristic species found in this community within the Park include: *Am-*

FIGURE 12. Dry–Mesic Northern Forest. July 17, 2016. Photo by David C. Dister.

FIGURE 13. Open Dunes—view north from Big Sable Point Lighthouse. October 22, 2008. Photo by David C. Dister.

mophila breviligulata, *Calamovilfa longifolia*, *Schizachyrium scoparium*, *Arabidopsis lyrata*, *Artemisia campestris*, *Cirsium pitcheri*, *Euphorbia polygonifolia*, *Lithospermum caroliniense*, *Monarda punctata*, *Solidago simplex*, *Hudsonia tomentosa*, *Prunus pumila*, and *Salix cordata*.

Great Lakes Barrens

Great Lakes barrens is a coniferous savanna community of scattered and clumped trees and an often dense, low or creeping shrub layer. The community occurs on circumneutral sands along the shores of the Great Lakes, where it is often associated with interdunal wetland and open dunes. (Cohen et al. 2015).

This plant community occurs predominantly in the northern third and the southern third of the Park east of the foredunes along Lake Michigan (Figures 1 and 14). Characteristic species found in this community within the Park include: *Artemisia campestris*, *Koeleria macrantha*, *Schizachyrium scoparium*, *Galium pilosum*, *Monarda punctata*, *Arctostaphylos uva-ursi*, *Hudsonia tomentosa*, *Juniperus communis*, *Prunus pumila*, *Shepherdia canadensis*, *Pinus banksiana*, *Pinus strobus*, and *Quercus velutina*.

DISCUSSION

The flora of Ludington State Park includes 444 taxa (including subspecies) based on this study and historic collecting of 15 taxa not found during this study. The flora diversity relies heavily on interdunal wetlands eastward of Lake Michigan, and palustrine wetlands bordering Hamlin Lake. This is reflected in 27 species of *Carex* and six species of *Juncus* documented in the Park. A total of 112 taxa were collected that are new records for Mason County.

As a consequence of the Park's soils being highly xeric and topsoil depths

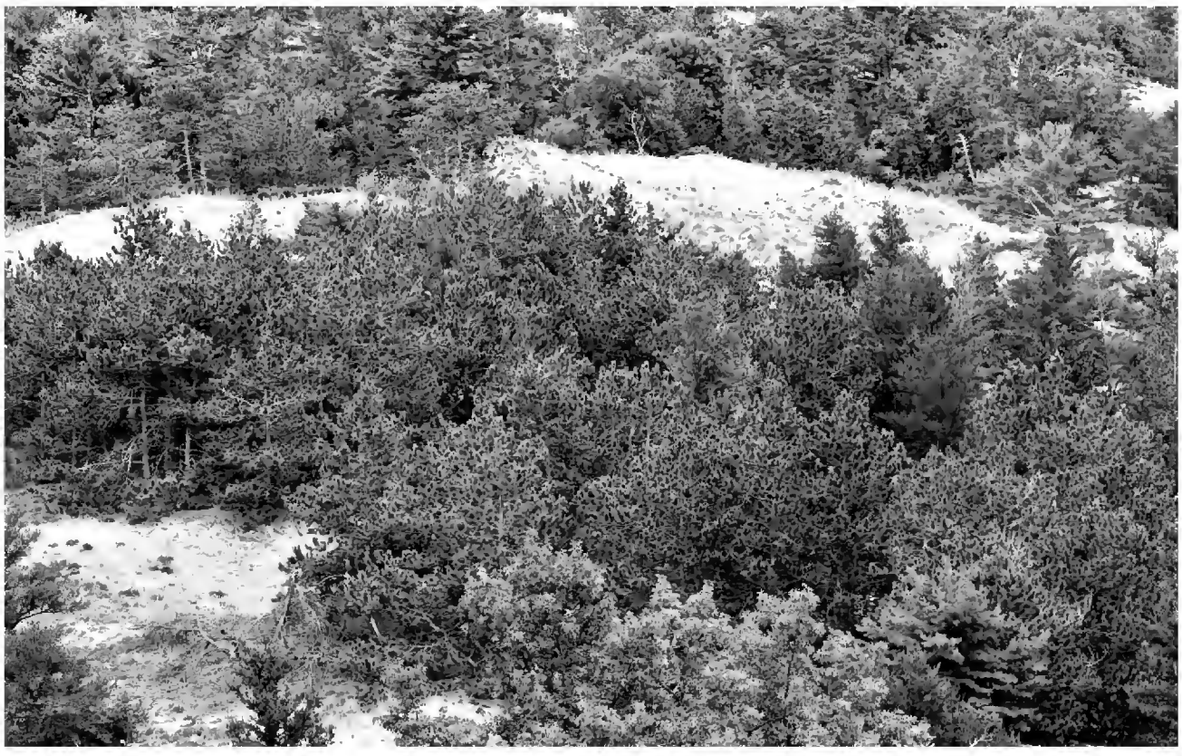

FIGURE 14. Great Lakes Barrens. July 15, 2016. Photo by David C. Dister.

being quite shallow, spring ephemeral wildflowers are relatively few. Among the most widespread spring ephemerals are *Maianthemum canadense*, *Maianthemum racemosum*, *Maianthemum stellatum*, *Polygonatum pubescens*, and *Trientalis borealis*. Interestingly, a small population of *Hepatica americana* was found in black loamy sand along the southeastern edge of the Park, which is the only location in the park with this mapped organic soil (USDA, NRCS, FS 1995).

The only state-listed taxon not previously documented at the Park is bugseed (*Corispermum pallasii)*, a Michigan Special Concern species, that was found September 11, 2011 in open dune habitat (Figure 5). Repeated annual efforts to re-locate two of the previously known state-listed taxa, *Cypripedium arietinum* and *Orobanche fasciculata*, were not successful during this study.

One of the most significant finds of a non-listed taxon was *Eriocaulon aquaticum* (Figure 6). More than 1,000 flowering plants were estimated to inhabit a mucky 1.5-acre interdunal wetland with *Schoenoplectus acutus* approximately one mile east of Lake Michigan when discovered on July 15, 2012. In succeeding summers, water levels were apparently too high, and there was no sign of germination. This taxon appears to be regionally rare based on rarity of the habitat and the author's other field work in Mason, Manistee and Lake Counties. Another noteworthy discovery was a population of the **native** common reed (*Phragmites australis* subsp. *americanus*) on July 27, 2014.

A determination of the $\bar{C}$ for the Park resulted in a score of 4.9, which compares with 5.1 determined by the author for the NDWA study by Hazlett (1986a, 1986b). Additionally, a determination of the *FQI* for the Park resulted in a score of 91.1, which compares with 91.5 determined by the author for the NDWA study (Hazlett 1986a, 1986b). The higher scores for both parameters at NDWA may re-

FIGURE 15. Ravine with extensive beech bark disease mortality. September 3, 2007. Photo by David C. Dister.

flect basic differences in management, as designated wilderness areas have much greater restrictions on human activity as compared to state parks. Also, 23 percent (102) of the vouchered taxa at the Park are considered non-native, whereas only 12 percent (43) are considered non-native at NDWA based on the Hazlett study conducted three decades earlier. Some of this discrepancy may be a result of much greater human interaction and visitation (with incidental introduction of non-natives), in the Park than in NDWA. A total of 34 taxa at LSP have a Coefficient of Conservatism (C) ranking of 9 or 10, which represents 8 percent of the 444 vouchered taxa (Table 2). In comparison, 33 taxa at NDWA also have a C ranking of 9 or 10, which represents 9 percent of the 365 vouchered taxa at that park (Hazlett 1986a, 1986b). These high rankings are not that dissimilar, despite the fact that the Park is much larger than NDWA. Negative impacts to the herbaceous flora of the Park are largely due to an excessive population of white-tailed deer (*Odocoileus virginianus*). Succulent taxa such as members of the Osmundaceae and Orchidaceae are especially sought after by browsing deer, and the modest diversity of orchid taxa found in the Park may be a reflection of this. Additionally, the deer herd population statewide appears to have been notably larger during the current study than during the NDWA study (Hazlett, 1986a, 1986b). A search of statewide herd estimates provided estimates of 1 million in 1981 (MDNR 2017) vs. 1.75 million in 2015 (Lansing State Journal 2017).

Negative impacts to forest canopy taxa in the Park are largely due to exotic pathogens and/or insects. Pathogens such as beech bark disease (Figure 15), is a *Neonectria* fungus spread by a sap-feeding scale insect (*Cryptococcus fagisuga*)

that causes mortality of *Fagus grandifolia*, while emerald ash borer (*Agrilus planipennis*) has similar effects upon *Fraxinus americana* and *F. pennsylvanica*, impacting the diversity of canopy taxa in the Park.

Lastly, surveys in deepwater aquatic bed communities were limited to wadable water depths, and more thorough surveys with the use of watercraft might result in additional taxa among *Potamogeton* and other aquatic genera. Similarly, new terrestrial taxa are likely to be introduced over time along roadways, trails, and campgrounds due to human activities.

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APPENDIX 1. ANNOTATED CHECKLIST OF THE VASCULAR FLORA OF LUDINGTON STATE PARK.

This list includes all taxa of vascular plants within Ludington State Park collected by the author during 2009 through 2014 and by other botanists during the 20th century. Except for Pteridophytes, the list is arranged according to Voss and Reznicek (2012). Ferns and lycopods are listed alphabetically by family, genus, and species following the classification in MICHIGAN FLORA ONLINE (2011). Common names are largely taken from Voss and Reznicek (2012), and also from the USDA Plants Database (2013-2016). Voucher specimens are deposited at the University of Michigan Herbarium (MICH). The Coefficient of Conservatism (***C***) numbers are taken from MICHIGAN FLORA ONLINE (2011). Collections by the author are indicated by D followed by the collection number, and collections by others of taxa not found in this study are as indicated by their last name, the collection number, and the year of collection in parentheses. These collectors are Harley H. Bartlett, Scott Herron, Florence V. Hoseney, N. W. Katz, Rogers McVaugh, and C. Marvin Rogers. The 15 historic vouchers in the Appendix are deposited at MICH (10), WUD (4), and BLH (1). For several taxa without vouchers, the phrase "photo voucher only" is noted.

The abundance of plant taxa are noted as follows: **rare** (scarce, small locality); **occasional** (scattered); **common** (many localities or individuals); **locally common** (not found often but abundant where found); and **abundant** (extremely common in most of the suitable habitat). Abundance is followed by the habitat within the Park where the taxon is typically found. "ND" indicates that no frequency or habitat information is available. Taxa marked with an asterisk (*) are alien taxa. Taxa marked with a dagger (†) represent new Mason County records.

PTERIDOPHYTES

CYSTOPTERIDACEAE (Bladder Fern Family)

Gymnocarpium dryopteris (L.) Newm.; Oak Fern; locally common on semi-open forested dunes; D373; ***C*** 5

DENNSTAEDTIACEAE (Bracken Fern Family)

Pteridium aquilinum (L.) Kuhn; Bracken Fern; locally common on mixed forested dunes; D125; ***C*** 0

DRYOPTERIDACEAE (Wood Fern Family)

Dryopteris carthusiana (Vill.) H. P. Fuchs; Spinulose Woodfern; occasional on shaded mixed forested dunes; D088; ***C*** 5

Dryopteris intermedia (Willd.) A. Gray; Evergreen Woodfern; locally common on shaded mixed forested dunes; D272; ***C*** 5

†*Dryopteris marginalis* (L.) A. Gray; Marginal Woodfern; rare on north slope of sugar maple forest; D309; ***C*** 5

EQUISETACEAE (Horsetail Family)

Equisetum arvense L.; Common Horsetail; locally common along steep shaded slope along Piney Ridge Lake (Lake Ann); D478; ***C*** 0

†*Equisetum fluviatile* L.; Water Horsetail; locally common in deepwater emergent wetlands; D298; ***C*** 7

Equisetum hyemale L.; Scouring Rush; locally common in low moist thickets; D306; ***C*** 2

†*Equisetum variegatum* Schleich.; Variegated Scouring Rush; locally common along moist edge of emergent wetlands; D307; ***C*** 6

LYCOPODIACEAE (Clubmoss Family)

†*Dendrolycopodium obscurum* (L.) A Haines; Ground-Pine; rare on mossy hummocks by edge of shaded wetland; D506; ***C*** 5

Diphasiastrum digitatum (A. Braun) Holub; Ground-Cedar; rare, in opening of mixed forested dune; D302; ***C*** 3

†*Huperzia lucidula* (Michx.) R. Trevis.; Shining Clubmoss; rare on steep east-facing logging road cut in forested dune; D187; ***C*** 5

ONOCLEACEAE (Sensitive Fern Family)

Onoclea sensibilis L.; Sensitive Fern; occasional along damp margins of wetlands; D287; ***C*** 2

OPHIOGLOSSACEAE (Grape-Fern Family)

Botrypus virginianus (L.) Michx.; Rattlesnake Fern; rare on deciduous forested dune; D366; **C** 5

OSMUNDACEAE (Flowering-Fern family)

Osmunda cinnamomea L.; Cinnamon Fern; occasional along wetland edges; D093; ***C*** 5

Osmunda regalis L.; Royal Fern; uncommon along wetland edges; D092; ***C*** 5

POYPODIACEAE (Polypody Family)

Polypodium virginianum L.; Common Polypody; fairly rare on steep slopes of old logging roads in mixed forested dunes; D102; ***C*** 8

SELAGINELLACEAE (Spikemoss Family)

Selaginella rupestris (L.) Spring; Sand Club Moss; ND; Bartlett s.n. (1937); ***C*** 3

THELYPTERIDACEAE (Marsh Fern Family)

Thelypteris palustris Schott; Marsh Fern; locally common along edge of emergent wetlands; D241; ***C*** 2

GYMNOSPERMS

CUPRESSACEAE (Cypress Family)

Juniperus communis L.; Ground Juniper; abundant in jack pine barrens, but occasional in open dunes; D279, ***C*** 4

Thuja occidentalis L.; White-Cedar; common in forested wetlands and occasional elsewhere; D291; ***C*** 4

PINACEAE (Pine Family)

Pinus banksiana Lamb.; Jack Pine; abundant in older/stable dune habitats; D281; ***C*** 5

Pinus strobus L.; White Pine; common in forested dunes and wetlands; D284; ***C*** 3

Tsuga canadensis (L.) Carrière; Eastern Hemlock; abundant in mixed forested dunes; D293; ***C*** 5

ANGIOSPERMS—MONOCOTS

ALISMATACEAE (Water-Plantain Family)

Sagittaria latifolia Willd.; Common Arrowhead; occasional in shallow water wetlands; D299; ***C*** 4

ARACEAE (Arum Family)

Calla palustris L.; Wild Calla; rare in semi-shaded backwater wetlands; D068; ***C*** 10

Lemna trisulca L.; Star Duckweed; rare in semi-shaded wetlands; D103; ***C*** 6

Lemna turionifera Landolt; Red Duckweed; locally common in semi-shaded wetlands; D342; ***C*** 5

Spirodela polyrhiza (L.) Schleid.; Greater Duckweed; rare in semi-shaded wetlands; D343; ***C*** 6

ASPARAGACEAE (Asparagus Family)

**Asparagus officinalis* L.; Garden Asparagus; rare in jack pine barrens; D411

CONVALLARIACEAE (Lily-of-the-Valley Family)

Maianthemum canadense Desf.; Canada Mayflower; common in mixed forested dunes; D039; ***C*** 4

Maianthemum racemosum (L.) Link; Solomon's-Plume; occasional in mixed forested dunes; D382; ***C*** 5

†*Maianthemum stellatum* (L.) Link; Starry Solomon's-Plume; occasional in jack pine barrens; D085; ***C*** 5

Polygonatum pubescens (Willd.) Pursh; Downy Solomon Seal; occasional in mixed forested dunes; D035, D116; ***C*** 5

CYPERACEAE (Sedge Family)

Carex alata Torr.; Winged Sedge; occasional along edges of wetlands; D104, D174; ***C*** 10

Carex aquatilis Wahlenb.; Water Sedge; locally common in deepwater emergent wetlands; D060; ***C*** 7

Carex arctata Boott; Drooping Woodland Sedge; occasional in mixed forested dunes; D041; ***C*** 3

Carex atlantica L. H. Bailey; Prickly Bog Sedge; occasional along edges of semi-shaded emergent wetlands; D491; ***C*** 7

Carex brunnescens (Pers.) Poir.; Brownish Sedge; occasional along edges of semi-shaded emergent wetlands; D371; ***C*** 5

†*Carex buxbaumii* Wahlenb.; Buxbaum's Sedge; locally common in sedge meadow within jack pine barrens; D489; ***C*** 10

Carex canescens L.; Silvery Sedge; occasional in alder thicket edge of interdunal wetland; D408; ***C*** 8

Carex communis L. H. Bailey; Fibrousroot Sedge; occasional in semi-shaded mixed forested or open dunes; D029, D488; ***C*** 2

Carex crinita Lam.; Fringed Sedge; occasional along edges of semi-shaded wetlands; D070; ***C*** 4

†*Carex deweyana* Schwein.; Dewey's Sedge; occasional in shaded mixed forested dunes; D089; D322; ***C*** 3

†*Carex disperma* Dewey; Softleaf Sedge; locally common along edge of semi-shaded wetlands; D492; ***C*** 10

Carex eburnea Boott; Bristleleaf Sedge; locally common on steep shaded sandy dune ridge; D022; ***C*** 7

Carex folliculata L.; Northern Long Sedge; rare, in shaded wetland swale near Hamlin Lake; D507; ***C*** 10

Carex garberi Fernald; Elk Sedge; locally common in draw-down margins of interdunal wetlands and lake margins; D044; ***C*** 8

Carex interior L. H. Bailey; Inland Sedge; occasional along edges of open wetlands; D064, D370; ***C*** 3

Carex intumescens Rudge; Greater Bladder Sedge; occasional along edges of semi-shaded wetlands: D071; ***C*** 3

†*Carex lacustris* Willd.; Lake Sedge; occasional along edges of semi-shaded wetlands; D066; ***C*** 6

†*Carex lasiocarpa* Ehrh.; Woollyfruit Sedge; locally common along edge of backwater slough wetlands; D095; ***C*** 8

†*Carex leptonervia* (Fernald) Fernald; Nerveless Woodland Sedge; occasional in shaded mixed forested dunes; D090; ***C*** 3

Carex muehlenbergii Willd.; Muhlenberg's Sedge; occasional on semi-shaded forested dune ridges; D462; ***C*** 7

Carex peckii Howe; Peck's Sedge; ND; Rogers 9262 (1953); ***C*** 3

Carex pensylvanica Lam.; Pennsylvania Sedge; common on shaded upland mixed forested dunes; D372; ***C*** 4

†*Carex pseudocyperus* L.; Cypress-like Sedge; occasional, along edges of semi-shaded wetlands; D063; ***C*** 5

†*Carex stipata* Willd.; Awlfruit Sedge; rare, along edges of semi-shaded wetlands; D091; ***C*** 1

†*Carex stricta* Lam.; Upright Sedge; rare on hummock of mixed forested wetland; D374; ***C*** 4

†*Carex viridula* Michx.; Little Green Sedge; locally common along mucky edge of interdunal wetland; D421; ***C*** 4

†*Carex vulpinoidea* Michx.; Fox Sedge; rare along semi-shaded roadside; D435; ***C*** 1

Cladium mariscoides (Muhl.) Torr.; Twig-Rush; occasional in interdunal wetlands, and locally common in wet meadow along south side of Big Sable River; D196; ***C*** 10

Cyperus bipartitus Kunth; Brook Nut Sedge; locally common in wet meadow along south side of Big Sable River; D189; ***C*** 3

†*Cyperus esculentus* L.; Yellow Nut Sedge; occasional along sandy north bank of Big Sable River; D355; ***C*** 1

Cyperus schweinitzii Torr.; Rough Sand Sedge; rare in open sandy dunes; D208; ***C*** 5

Cyperus strigosus L.; Long Scaled Nut Sedge; occasional in wet meadow north of Big Sable River; D269; ***C*** 3

Dulichium arundinaceum (L.) Britton; Three-way Sedge; fairly common in shallow water wetlands; D167; ***C*** 8

Eleocharis elliptica Kunth; Golden-seeded Spike-Rush; locally common in interdunal wetlands; D158; ***C*** 6

Eleocharis palustris (L.) Roem. & Schult.; Common Spike-Rush; locally common in sedge/willow interdunal wetlands; D463; ***C*** 5

†*Eleocharis quinqueflora* (Hartmann) O. Schwarz; Few-flowered Spike-Rush; locally common in interdunal wetlands; D442; ***C*** 10

Fimbristylis autumnalis (L.) Roem. & Schult.; Autumn Sedge; rare, along draw-down sandy edge of Piney Ridge Lake; D362; ***C*** 6

†*Rhynchospora capillacea* Torr.; Needle Beak-Rush; occasional, in wet meadow south of Big Sable River; D198; ***C*** 10

†*Schoenoplectus acutus* (Bigelow) Á. Löve & D. Löve; Hardstem Bulrush; locally common in interdunal wetlands; D217; ***C*** 5

Schoenoplectus pungens (Vahl) Palla; Threesquare; locally common in interdunal wetlands; D078, D131; ***C*** 5

†*Schoenoplectus subterminalis* (Torr.) Soják; Swaying Bulrush; occasional in aquatic bed wetlands; D391, D426; ***C*** 8

Schoenoplectus tabernaemontani (C. C. Gmel.) Palla; Softstem Bulrush; occasional, in wet meadow south of Big Sable River; D433; ***C*** 4

Scirpus cyperinus (L.) Kunth; Wool-Grass; occasional, in interdunal marshes; D220; ***C*** 5

ERIOCAULACEAE (Pipewort Family)

Eriocaulon aquaticum (Hill) Druce; Sevenangle Pipewort; rare along mucky edges of old interdunal wetland; D420; ***C*** 9

HYDROCHARITACEAE (Frog's-Bit Family)

Elodea canadensis Michx.; Common Waterweed; fairly common in aquatic bed wetlands; D390; ***C*** 1

Vallisneria americana Michx.; Eel-Grass; locally common in aquatic bed wetlands; D250; ***C*** 7

IRIDACEAE (Iris Family)

**Iris pseudoacorus* L.; Yellow Flag; rare, in wetland slough off Hamlin Lake; D067

†*Iris versicolor* L.; Wild Blue Flag; locally common along edges of shaded wetlands; D058; ***C*** 5

†*Sisyrinchium montanum* Greene; Mountain Blue-Eyed-Grass; rare along grassy trail edge through jack pine barrens; D453, D457; ***C*** 4

JUNCACEAE (Rush Family)

Juncus alpinoarticulatus Chaix; Northern Green Rush; occasional along edges of interdunal emergent wetlands; D218; ***C*** 5

Juncus balticus Willd.; Baltic Rush; occasional along edges of interdunal wetlands and drawdown lake margins; D439, D497; ***C*** 4

†*Juncus brachycephalus* (Engelm.) Buchenau; Smallhead Rush; occasional in wet meadow south of Big Sable River; D432; ***C*** 7

†*Juncus dudleyi* Weigand; Dudley's Rush; occasional, along moist shaded trailsides and wetland edges; D252; ***C*** 1

Juncus effusus L.; Soft-stemmed Rush; occasional in scrub-shrub and other shallow water wetlands; D266, D445; ***C*** 3

†*Juncus nodosus* L.; Joint Rush; occasional in interdunal wetlands; D230; ***C*** 5

JUNCAGINACEAE (Arrow-Grass Family)

Triglochin maritima L.; Common Bog Arrow-Grass; rare in interdunal wetlands; D110; ***C*** 8

Triglochin palustris L.; Slender Bog Arrow-Grass; abundant in wet sand in interdunal hollows; McVaugh 11193 (1949); ***C*** 8

MELANTHIACEAE (Bunchflower Family)

Anticlea elegans (Pursh) Rydb.; White Camas; fairly rare on open dunes; D111; ***C*** 10

ORCHIDACEAE (Orchid Family)

Corallorhiza odontorhiza (Willd.) Nutt.; Fall Coral-Root; rare in semi-shaded mixed forested dune; D363; ***C*** 8

Cypripedium arietinum R Br.; Ram's Head Lady Slipper; rare in jack pine barrens; photo voucher only (Figure 4); *C* 10

**Epipactis helleborine* (L.) Crantz; Helleborine; rare in semi-shaded mixed forested dune; D341

Goodyera oblongifolia Raf.; Menzies' Rattlesnake Plantain; rare on moss-covered steep semi-shaded dune; D027; ***C*** 8

†*Liparis loeselii* (L.) Rich.; Green Twayblade; rare, in saturated sedge meadow fringe bordering deepwater wetlands; D466; ***C*** 5

Spiranthes cernua (L.) Rich.; Nodding Ladies'-Tresses; occasional, along margins of interdunal wetlands; D214; ***C*** 4

†*Spiranthes lacera* (Raf.) Raf.; Slender Ladies'-Tresses; rare in jack pine/ground juniper barrens; D461; ***C*** 8

POACEAE (Grass Family)

**Agrostis gigantea* Roth; Redtop; occasional in wet meadow north of Big Sable River; D133

Agrostis perennans (Walter) Tuck.; Autumn Bent; occasional in semi-shaded emergent wetlands; D467; ***C*** 5

Agrostis scabra Willd.; Ticklegrass; occasional in open emergent marsh/interdunal wetlands; D162, D496; ***C*** 4

Ammophila breviligulata Fernald; Beach Grass; abundant on foredunes and beach margins fronting Lake Michigan; D226; ***C*** 10

†*Andropogon virginicus* L.; Broom-Sedge; rare in moist meadow south of Piney Ridge Lake; D443; **C** 4

Avenella flexuosa (L.) Drejer; Hairgrass; occasional on semi-shaded mixed forested dunes; D069; ***C*** 6

Bromus ciliatus L.; Fringed Brome; rare, under white pine with *Linnaea* and *Mitchella*; Katz 692 (1951); ***C*** 6

**Bromus inermis* Leyss.; Smooth Brome; occasional along Piney Ridge Road/east edge of park; D437

*†*Bromus tectorum* L.; Downy Chess; occasional in semi-open jack pine/black oak barrens; D124

Calamagrostis canadensis (Michx.) P. Beauv.; Blue-Joint; fairly common in interdunal emergent wetlands; D144, D215, D460; ***C*** 3

Calamagrostis stricta (Timm) Koeler; Narrow-leaved Reedgrass; abundant in low places amongst dunes along Lake Michigan; McVaugh 12649 (1951); ***C*** 10

Calamovilfa longifolia (Hook.) Scrib.; Sand Reed Grass; common to abundant on open dunes; D197, D275; ***C*** 10

Cenchrus longispinus (Hack.) Fernald; Sandbur; rare, in disturbed sandy area north of Hamlin Beach parking lot; D345; ***C*** 0

**Dactylis glomerata* L.; Orchard Grass; occasional along roadsides and forested dune openings; D143

Danthonia spicata (L.) Roem. & Schult.; Poverty Grass; rare, in low opening within jack pine barrens; D498; ***C*** 4

†*Dichanthelium commonsianum* (Ashe) Freckmann; Hemlock Rosette Grass; occasional on open dunes; D321; ***C*** 6

Dicanthelium implicatum (Schribn.) Kerguélen; Western Panic Grass; abundant in jack pine barrens, common in wet meadow south of Big Sable River; D190, D340; ***C*** 3

†*Dicanthelium xanthophysum* (A. Gray) Freckmann; Slender Rosette Grass; rare in semi-shaded mixed forested dunes; D383; ***C*** 6

†*Digitaria cognata* (Schult.) Pilg.; Fall Witch Grass; occasional, grassy edge along paved walkway; D245; ***C*** 3

*†*Digitaria ischaemum* (Schreb.) Muhl.; Smooth Crab Grass; locally common along edge of semi-shaded paved road; D434

†*Echinochloa muricata* (P. Beauv.) Fernald; Rough Barnyard Grass; rare, along shallow rocky edge of Big Sable River; D347; ***C*** 1

Elymus canadensis L.; Canada Wild Rye; occasional on open dunes; D235; ***C*** 5

**Elymus repens* (L.) Gould; Quack Grass; rare, open grassy disturbed dune areas; D223

†*Eragrostis pectinacea* (Michx.) Nees; Love Grass; rare; along grassy open 2-track road through jack pine barrens; D471; ***C*** 0

†*Eragrostis spectabilis* (Pursh) Steud.; Tumble Grass; rare, on steep sandy bank of Big Sable River; D356; ***C*** 3

*†*Festuca trachyphylla* (Hack.) Krajina; Sheep Fescue; rare, in disturbed forested campgrounds; D490

†*Glyceria borealis* (Nash) Batch.; Northern Manna Grass; occasional in shallow water emergent wetlands; D414; ***C*** 6

Glyceria canadensis (Michx.) Trin.; Rattlesnake Grass; rare, along edges of interdunal wetlands/marshes; D168; ***C*** 8

Glyceria striata (Lam.) Hitch.; Fowl Manna Grass; occasional in semi-shaded mixed forested wetlands; D065; ***C*** 4

Koeleria macrantha (Ledeb.) Schult.; June Grass; occasional in semi-open jack pine barrens; D161; ***C*** 9

†*Leersia oryzoides* (L.) Sw.; Cut Grass; occasional in emergent marshes; D295; ***C*** 3

*†*Leymus arenarius* (L.) Hochst; Lyme Grass; rare in open dunes; D210

*†*Lolium perenne* L.; Ryegrass; rare, semi-shaded grassy slope by river boardwalk; D138

Muhlenbergia mexicana (L.) Trin.; Leafy Satin Grass; occasional, open wet sandy habitats; D259; ***C*** 3

†*Muhlenbergia schreberi* J. F. Gmel.; Nimblewill; locally common in forested dune openings; D399; ***C*** 0

Oryzopsis asperifolia Michx.; Rough-leaved Rice-Grass; occasional in mixed forested dunes; D010; ***C*** 6

Panicum virgatum L.; Switch Grass; abundant in low places among dunes; McVaugh 12650 (1951); ***C*** 4

†*Patis racemosa* (Sm.) Romasch., P. M. Peterson & Soreng (syn. *Piptatherum racemosum* (Sm.) Eaton); Black Seed Rice Grass; rare on deciduous forested dune ridgetops; D256; ***C*** 8

Phalaris arundinacea L.; Reed Canary Grass; occasional along riparian and wetland edges; D129; ***C*** 0

**Phleum pratense* L.; Timothy; rare, in semi-shaded mixed forested dunes and roadsides; D142

†*Phragmites australis* subsp. *americanus* (Cav.) Steud.; American Common Reed; rare, small colony in open shallow emergent marsh; D495; ***C*** 5

*†*Phragmites australis* subsp. *australis* (Cav.) Steud.; European Common Reed; locally common in interdunal wetlands; D145

*†*Poa bulbosa* L.; Bulbous Bluegrass; occasional in disturbed campgrounds; D021
**Poa compressa* L.; Canada Bluegrass; locally common on deciduous forested dune ridgetops and forest openings/roadsides; D057
**Poa pratensis* subsp. *angustifolia* (L.) Lej.; Kentucky Bluegrass; locally common on open disturbed sites; D222
**Poa pratensis* subsp. *pratensis* L.; Kentucky Bluegrass; locally common in sedge meadow wetlands; D409
Schizachne purpurascens (Torr.) Swallen; False Melic; occasional in semi-shaded forested dunes; D114, D367; ***C*** 5
Schizachyrium scoparium (Michx.) Nash; Little Bluestem; fairly common in open dunes and jack pine barrens; D225; ***C*** 5
*†*Setaria pumila* (Poir.) Roem. & Schult.; Yellow Foxtail; occasional along sandy open banks of the Big Sable River; D354
**Setaria viridis* (L.) P. Beauv.; Green Foxtail; occasional along edges of roadsides, parking lots, and other disturbed habitats; D254
Sporobolus cryptandrus (Torr.) A. Gray; Sand Dropseed; rare, sandy disturbed zone north of Hamlin Beach parking lot; D349; ***C*** 3
Zizania palustris L.; Northern Wild Rice; occasional in deepwater aquatic bed/emergent marshes; D177; ***C*** 8

PONTEDERIACEAE (Pickerel-Weed Family)
Heteranthera dubia Jacq.; Water Star-Grass; rare in deepwater aquatic bed/emergent marshes; D389; ***C*** 6
Pontederia cordata L.; Pickerel-Weed; occasional in deepwater aquatic bed/emergent marshes; D176; ***C*** 8

POTAMOGETONACEAE (Pondweed Family)
*†*Potamogeton crispus* L.; Curly Pondweed; rare in deepwater aquatic bed wetlands; D378
Potamogeton friesii Rupr.; Fries's Pondweed; occasional in deepwater aquatic bed wetlands; D416; ***C*** 6
Potamogeton gramineus L.; Variableleaf Pondweed; occasional in deepwater aquatic bed wetlands; D084; ***C*** 5
Potamogeton zosteriformis Fernald; Flat-Stemmed Pondweed; occasional in deepwater aquatic bed wetlands; D415; ***C*** 5
Stuckenia pectinata (L.) Börner; Sago Pondweed; Lost Lake; Bartlett s.n. (1937); ***C*** 3

TYPHACEAE (Cat-Tail or Bur-Reed Family)
Sparganium eurycarpum Engelm.; Common Bur-Reed; occasional in emergent marsh wetlands; D257; ***C*** 5
†Sparganium natans L.; Small Bur-Reed; locally common in aquatic bed/emergent marsh wetlands; D242; ***C*** 8
**Typha angustifolia* L.; Narrow-Leaf Cat-Tail; locally common in deepwater aquatic bed/emergent marsh wetlands; D 182
Typha latifolia L.; Common Cat-Tail; occasional in deepwater aquatic bed/emergent marsh wetlands; D334; ***C*** 1

ANGIOSPERMS—DICOTS

ADOXACEAE (Moschatel Family)
Sambucus canadensis L.; Common Elderberry; rare, in thickets along Big Sable River; D206; ***C*** 3
Sambucus racemosa L.; Red Elderberry; rare, on east slope of remote forested dune; D053; ***C*** 3
Viburnum acerifolium L.; Maple-leaved Viburnum; locally common in mixed forested dunes; D237; ***C*** 6
*†*Viburnum opulus* L.; European Highbush-Cranberry; rare, in scrub-shrub wetland; D308

AMARANTHACEAE (Amaranth Family)
*†*Chenopodium album* L.; Lamb's-Quarters; rare in disturbed habitats; D504

FIGURE 16. *Rhus typhina.* April 21, 2017. Photo by David C. Dister.

Corispermum pallasii Steven; Bugseed; occasional on open dunes; D393; ***C*** 3

**Cycloloma atriplicifolium* (Spreng.) J. M. Coult.; Winged Pigweed; occasional on open dunes; D292

**Salsola tragus* L.; Russian-Thistle; rare, in sedge meadow; D440

ANACARDIACEAE (Sumac Family)

Rhus typhina L.; Staghorn Sumac; rare, along grassy roadside; photo voucher only (Figure 16); ***C*** 2

Toxicodendron rydbergii (Rydb.) Greene; Western Poison-Ivy; locally common in grassy dunes; D454; ***C*** 3

APIACEAE (Carrot Family)

*†*Cicuta bulbifera* L.; Water-Hemlock; occasional in emergent wetlands; D251; ***C*** 5

**Daucus carota* L.; Wild Carrot; rare in open dunes and disturbed habitats; D153

Osmorhiza claytonii (Michx.) C. B. Clarke; Hairy Sweet-Cicely; rare in mixed forested dunes; D042; ***C*** 4

Sium suave Walter; Water-Parsnip; occasional in emergent wetlands; D184; ***C*** 5

**Torilis japonica* (Houtt.) DC.; Hedge-Parsley; rare on steep shaded forested dune; D201

APOCYNACEAE (Dogbane Family)

Asclepias incarnata L.; Swamp Milkweed; occasional in emergent wetlands; D377; ***C*** 6

Asclepias syriaca L.; Common Milkweed; occasional in open dunes; D107; ***C*** 1

AQUIFOLIACEAE (Holly Family)

Ilex verticillata (L.) A. Gray; Winterberry; occasional along shrubby margins of emergent wetlands; D261; ***C*** 5

FIGURE 17. *Aralia nudicaulis*. Leaves depicted. August 24, 2014. Photo by David C. Dister.

ARALIACEAE (Ginseng Family)

Aralia nudicaulis L.; Wild Sarsaparilla; rare in mixed forested dunes; photo voucher only (Figure 17); ***C*** 5

ASTERACEAE (Aster Family)

Achillea millefolium L.; Yarrow; occasional along grassy margins of roadways and parking lots; D105; ***C*** 1

Ambrosia artemisiifolia L.; Common Ragweed; rare, grassy steep bank of Big Sable River; D352; ***C*** 0

*†*Ambrosia psilostachya* DC.; Western Ragweed; rare; disturbed sandy parking lot southeast of Lighthouse; D394

Anaphalis margaritacea (L.) Benth. & Hook.; Pearly Everlasting; occasional in jack pine barrens; D212; ***C*** 3

Antennaria howellii Greene; Small Pussytoes; rare, semi-shaded north slope of mixed forested dune; D025; ***C*** 2

Antennaria parlinii Fernald; Smooth Pussytoes; rare, semi-shaded east slope of mixed forested dune; D365; ***C*** 2

*†*Arctium minus* Bernh.; Common Burdock; rare, along slopes by Big Sable River boardwalk; D357

Artemisia campestris L.; Wild Wormwood; common in open dunes; D209; ***C*** 5

*†*Bellis perennis* L.; English Daisy; locally common, in lawn by park office; D317

Bidens beckii Spreng.; Water-Marigold; locally common, shaded deepwater wetland sloughs; D183; ***C*** 10

†*Bidens cernua* L.; Nodding Bur-Marigold; occasional in emergent marsh wetlands; D265; ***C*** 3

†*Bidens connata* Muhl.; Purple-Stemmed Tickseed; rare, along sandy vegetated north edge of Piney Ridge Lake; D474; ***C*** 5

†*Bidens discoidea* (Torr. & A. Gray); Britton; Swamp Beggar-Ticks; rare, mostly shaded emergent marsh; D240; ***C*** 7

**Centaurea stoebe* L.; Spotted Knapweed; common in open dunes and meadows; D232

**Cichorium intybus* L.; Chickory; occasional on open dunes/ roadsides bordering M-116; D154

*†*Cirsium arvense* (L.) Scop.; Canada Thistle; rare, forest openings and disturbed wetlands; D135

Cirsium pitcheri (Torr.) Torr. & A. Gray; Pitcher's Thistle; sand dune – interdune; Herron 183 (2000); ***C*** 10

**Cirsium vulgare* (Savi.) Ten; Bull Thistle; rare, disturbed open grassy habitats; D221

Conyza canadensis (L.) Cronq.; Horseweed; occasional in wet meadows and disturbed areas; D191, D464; ***C*** 0

†*Erechtites hieraciifolia* (L.) Raf.; Fireweed; rare, dry hummock within emergent marsh wetland; D229; ***C*** 2

†*Erigeron philadelphicus* L.; Common Fleabane; rare; open willow/honeysuckle thicket; D045; ***C*** 2

Eupatorium perfoliatum L.; Common Boneset; occasional in emergent marsh wetlands and lake margins; D233; ***C*** 4

Eurybia macrophylla (L.) Cass.; Large-Leaved Aster; rare, base of steep mixed forested dune along Piney Ridge Road; D311; ***C*** 4

Euthamia graminifolia (L.) Nutt.; Grass-Leaved Goldenrod; occasional in wet meadows and interdunal wetlands; D236; ***C*** 3

**Hieracium caespitosum* Dumort.; Yellow Hawkweed; occasional in openings of jack pine barrens and forested dunes; D081, D101

**Hypochaeris radicata* L.; Cat's-Ear; occasional in wet meadows and disturbed areas; D134

Krigia virginica (L.) Willd.; Dwarf Dandelion; rare, openings in forested dunes and jack pine barrens; D405; ***C*** 4

**Leucanthemum vulgare* Lam.; Ox-Eye Daisy; rare; wet meadow south of Big Sable River; D077

Packera paupercula Michx.; Northern Ragwort; rare in open dunes; D048; ***C*** 3

Pseudognaphalium macounii (Greene) Kartesz; Clammy Cudweed; rare, along base of active dune by jack pine barrens; D227; ***C*** 2

†*Pseudognaphalium obtusifolium* (L.) Hilliard & B. L. Burtt; Fragrant Cudweed; rare, open mixed forested ravine with massive American beech die-off; D263; ***C*** 2

Solidago altissima L.; Tall Goldenrod; occasional, in grassy meadows; D234, D360; ***C*** 1

Solidago caesia L.; Bluestem Goldenrod; rare, along edge of forested back dune; D278; ***C*** 6

Solidago nemoralis Aiton; Gray Goldenrod; rare, sandy old field with open ground patches; D480; ***C*** 2

Solidago rugosa Mill.; Rough-leaved Goldenrod; rare, damp meadow along south edge of Piney Ridge Lake; D479; ***C*** 3

Solidago simplex Kunth; Gillman's Goldenrod; occasional on open dunes; D274; ***C*** 10

*†*Sonchus arvensis* L.; Prickly Sow-Thistle; rare, on grassy hummock by edge of Hamlin Lake; D180

Symphyotrichum dumosum (L.) G. L. Nesom; Bushy Aster; rare, in damp meadow along south edge of Piney Ridge Lake; D477; ***C*** 7

Symphyotrichum laeve (L.) G. L. Nesom; Smooth Aster; rare, along west edge of forested dune bordering grassy opening; D473; ***C*** 5

Symphyotrichum lateriflorum (L.) Á. Löve & D. Löve; Calico Aster; occasional in wet meadow south of Big Sable River; D476; ***C*** 2

Symphyotrichum pilosum var. *pringlei* (A. Gray) G. L. Nesom; Hairy Aster; occasional in wet meadow south of Big Sable River and along roadsides; D195, D392; ***C*** 1

**Taraxacum officinale* F. H. Wigg.; Dandelion; occasional in disturbed habitats and rare elsewhere; D011

**Tragopogon dubius* Scop.; Goat's Beard; rare along roadsides; D324

*†*Xanthium strumarium* L.; Common Cocklebur; rare along Lake Michigan beaches; D276

BALSAMINACEAE (Jewelweed Family)

Impatiens capensis Meerb.; Spotted Touch-Me-Not; occasional in emergent marsh wetlands; D253; ***C*** 2

BERBERIDACEAE (Barberry Family)

**Berberis aquifolium* Pursh; Oregon-Grape; rare, in jack pine barrens and the south edge of Piney Ridge Lake; D108

**Berberis thunbergii* DC.; Japanese Barberry; common in jack pine barrens and forested dune habitats; D023

**Berberis vulgaris* L; Common Barberry; rare along shrubby edge of gravel road to the Lighthouse; D704

BETULACEAE (Birch Family)

Alnus incana (L.) Moench; Speckled Alder; locally common along wetland margins of the Big Sable River; D247; ***C*** 5

Betula alleghaniensis Britton; Yellow Birch; rare in forested wetlands; D388; ***C*** 7

Betula papyrifera Marshall; Paper Birch; occasional in jack pine barrens and forested dunes; D280; ***C*** 2

Ostrya virginiana (Mill.) K. Koch; Hop-Hornbeam; occasional in forested dunes; D051; ***C*** 5

BORAGINACEAE (Borage Family)

Cynoglossum boreale Fernald; Northern Wild Comfrey; rare in jack pine barrens south of Big Sable River; D452; ***C*** 7

*†*Cynoglossum officinale* L.; Hound's-Tongue; common in jack pine barrens; D028

*†*Echium vulgare* L.; Viper's Bugloss; occasional in jack pine barrens; D082

†*Hackelia deflexa* (Wahlenb.) Opiz; Nodding Stickseed; rare, openings and edges of forested dunes; D118; ***C*** 2

Lithospermum caroliniense (Walter) MacMill; Hairy Puccoon; common in open dunes and jack pine barrens; D030; ***C*** 10

*†*Lithospermum officinale* L.; Gromwell; rare in jack pine barrens; D486

*†*Myosotis arvensis* (L.) Hill; Field Scorpion-Grass; rare along margins of interdunal and emergent wetlands; D074

BRASSICACEAE (Mustard Family)

*†*Alliaria petiolata* (M. Bieb.) Cavara & Grande; Garlic Mustard; rare in disturbed forested dunes and roadsides; D014

Arabidopsis lyrata (L.) O'Kane & Al-Shehbaz; Sand Cress; common in open and semi-vegetated dunes; D015, D451; ***C*** 7

**Barbarea vulgaris* R. Br.; Yellow Rocket; occasional along weedy trailsides; D016

†*Boechera laevigata* (Willd.) Al-Shehbaz; Smooth Bank Cress; rare in mixed forested dunes; D040; ***C*** 5

**Berteroa incana* (L.) DC.; Hoary Alyssum; occasional along open trailsides; D136

Cakile edentula (Bigelow) Hook.; Sea-Rocket; occasional along high water mark of Lake Michigan beaches; D346; ***C*** 5

**Capsella bursa-pastoris* (L.) Medik.; Shepherd's-Purse; occasional along open roadsides; D076

**Cardamine hirsuta* L.; Hoary Bitter Cress; occasional along disturbed roadsides and openings in forested dunes; D017, D315

Cardamine pensylvanica Willd.; Pennsylvania Bitter Cress; occasional in semi-shaded shallow wetlands; D244; ***C*** 1

*†*Draba verna* L.; Whitlow-Grass; rare, in open sandy, weedy lawn by Hamlin Beach House; D400

*†*Erucastrum gallicum* (Willd.) Schulz; Dog-Mustard; rare in open dunes; D159

**Lepidium campestre* (L.) R. Br.; Field Cress; rare in disturbed openings/ edges of forested dunes; D075

†*Lepidium virginicum* L.; Common Peppergrass; rare in disturbed vegetated dunes; D505; ***C*** 0

**Lunaria annua* L.; Money-Plant; rare in exposed wetland edge along Piney Ridge Road; D403

FIGURE 18. *Lobelia cardinalis*. September 3, 2007. Photo by David C. Dister.

Rorippa palustris (L.) Besser; Yellow Cress; rare along margins of interdunal emergent wetlands; D337; ***C*** 1

CABOMBACEAE (Water-Shield Family)

Brasenia schreberi J. F. Gmel.; Water-Shield; locally common in aquatic bed and emergent wetlands; D294; ***C*** 6

CAMPANULACEAE (Bellflower Family)

Campanula aparinoides Pursh; Marsh Bellflower; rare, in emergent wetlands along west side of Lost Lake; D165; ***C*** 7

Campanula rotundifolia L.; Harebell; occasional in open dunes: D112; ***C*** 6

Lobelia cardinalis L.; Cardinal-flower; rare in emergent marshes; photo voucher only (Figure 18); ***C*** 7

Lobelia kalmii L.; Kalm's Lobelia; occasional in wet meadow south of Big Sable River; D188; ***C*** 10

CAPRIFOLIACEAE (Honeysuckle Family)

Lonicera canadensis Marshall; Canadian Fly-Honeysuckle; rare, by shaded roadside edge of mixed forested dune; D369; ***C*** 5

Lonicera dioica L.; Glaucous Honeysuckle; rare, in semi-open jack pine barrens by emergent wetland; D163; ***C*** 5

*†*Lonicera morrowii* A. Gray; Morrow Honeysuckle; locally common, in shrubby low thicket with willows northwest of Piney Ridge Lake; D046

CARYOPHYLLACEAE (Pink Family)

**Arenaria serpyllifolia* L.; Thyme-leaved Sandwort; occasional in semi-open forested dunes; D026

**Dianthus armeria* L.; Deptford Pink; rare, in sandy meadow north of Big Sable River; D204

**†Gypsophila paniculata* L.; Baby's Breath; rare, in open dunes along gravel road to Lighthouse; D418

**Petrorhagia saxifraga* (L.) Link; Saxifrage Pink; rare, in open dunes along gravel road to Lighthouse; D231

**†Saponaria officinalis* L.; Bouncing Bet; occasional in open dunes along M-116; D151

Silene antirrhina L.; Sleepy Catchfly; rare, in semi-open jack pine barrens; D083; ***C*** 2

**Silene latifolia* Poir.; White Campion; rare, on steep grassy slope south of Big Sable River; D137

**Silene vulgaris* (Moench) Garcke; Bladder Campion; occasional, in open dunes and openings in forested dunes; D106

**Stellaria media* (L.) Vill.; Common Chickweed; ND; Rogers 9289 (1953)

CELASTRACEAE (Bittersweet Family)

†Celastrus scandens L.; American Bittersweet; rare, in moist thickets and along roadsides; D310; ***C*** 3

CISTACEAE (Rockrose Family)

Crocanthemum canadense (L.) Britton; Canada Frostweed; occasional in forested dune openings; D344; ***C*** 8

Hudsonia tomentosa Nutt.; Beach-Heath; locally common in open dunes; D080; ***C*** 10

CONVOLVULLACEAE (Morning-Glory Family)

†Calystegia sepium (L.) R. Br.; Hedge Bindweed; rare, disturbed marshy west edge of Hamlin Lake; D099; ***C*** 2

CUCURBITACEAE (Gourd Family)

Sicyos angulatus L.; Bur-Cucumber; rare, trailing over osier dogwood along Big Sable River; Hoseney s.n. (1973); ***C*** 2

CORNACEAE (Dogwood Family)

Cornus rugosa Lam.; Round-leaved Dogwood; rare, small dense stand on east-facing steep deciduous forested dune along Piney Ridge Road; D052; ***C*** 6

Cornus sericea L.; Red-Osier Dogwood; occasional along wetland margins; D049; ***C*** 2

DIERVILLACEAE (Bush-Honeysuckle Family)

Diervilla lonicera Mill.; Bush-Honeysuckle; rare on semi-open forested slope south of Piney Ridge Lake; D325; ***C*** 4

DROSERACEAE (Sundew Family)

Drosera rotundifolia L.; Round-leaved Sundew; rare on mossy hummocks in emergent wetlands bordering Hamlin Lake; D033; ***C*** 6

ELAEAGNACEAE (Oleaster Family)

**†Elaeagnus umbellata* Thunb.; Autumn-Olive; rare, in low willow thickets northwest of Piney Ridge Lake; D056

Shepherdia canadensis (L.) Nutt.; Soapberry; rare in semi-open jack pine barrens east of M-116 at south end of park, and shrubby meadow south of Piney Ridge Lake; D160; ***C*** 7

ERICACEAE (Heath Family)

Arctostaphylos uva-ursi (L.) Spreng.; Bearberry; common in jack pine barrens; D157; ***C*** 8

Chamaedaphne calyculata (L.) Moench; Leatherleaf; fairly common in shallow wetlands near Hamlin Lake, though rare in interior wetlands; D 009; ***C*** 8

Chimaphila maculata (L.) Pursh; Spotted Wintergreen; rare, moderately steep east-facing slope in mixed forested dune; D396; ***C*** 8

Chimaphila umbellata (L.) W.P.C. Barton; Pipsissewa; rare in mixed forested dunes; photo voucher only (Figure 19); ***C*** 8

Epigaea repens L; Trailing-Arbutus; rare on shaded moss-covered slopes in mixed forested dunes; D100; ***C*** 7

Gaultheria procumbens L.; Wintergreen; locally common in semi-shaded mixed forested dunes; D338; ***C*** 5

FIGURE 19. *Chimaphila umbellata*. Leaves depicted. July 12, 2009. Photo by David C. Dister.

Gaylussacia baccata (Wangenh.) K. Koch; Huckleberry; locally common in mixed forested dunes and along margins of wetlands; D061; ***C*** 7

Hypopitys monotropa Crantz; Pinesap; rare on upland mixed forested dune ridge; D472; ***C*** 6

Monotropa uniflora L.; Indian-Pipe; rare in shaded mixed forested dunes with deep leaf litter; D173; ***C*** 5

Pyrola elliptica Nutt.; Large-leaved Shinleaf; rare along moist edge of mixed forested dune by aquatic bed wetland; D375; ***C*** 6

Vaccinium angustifolium Aiton; Low Sweet Blueberry; locally common in mixed forested dunes; D036; ***C*** 4

Vaccinium macrocarpon Aiton; Large Cranberry; locally common on mossy hummocks of emergent wetlands; D300; ***C*** 8

Vaccinium myrtilloides Michx.; Velvetleaf Blueberry; occasional in mixed forested dunes; D062; ***C*** 4

EUPHORBIACEAE (Spurge Family)

Euphorbia polygonifolia L.; Seaside Spurge; occasional on open dunes; D273; ***C*** 10

FABACEAE (Bean Family)

Lathyrus japonicus Willd.; Beach Pea; fairly rare in open dunes and semi-open jack pine barrens; D113; ***C*** 10

Lathyrus palustris var. *myrifolius* L.; Marsh Pea; rare in emergent wetlands along west side of Lost Lake; D166; ***C*** 7

**Medicago lupulina* L.; Black Medick; occasional along edges of gravel trails and roads; D199

*†*Medicago sativa* L.; Alfalfa; rare, in grassy opening of pine forest; D336

**Melilotus albus* Medik.; White Sweet-Clover; rare, along sandy south edge of Big Sable River; D128

*†*Trifolium arvense* L.; Rabbitfoot Clover; rare, in sandy disturbed site adjacent to emergent wetland; D120

**Trifolium hybridum* L.; Alsike Clover; rare, on semi-open grassy slope by Big Sable River boardwalk; D139

**Trifolium pratense* L.; Red Clover; rare, in open grassy meadow near Warming Shelter; D207

**Trifolium repens* L.; White Clover; occasional, in wet meadow south of Big Sable River, along trails, lawns, etc.; D079, D386

*†*Vicia sativa* L.; Common Vetch; rare, in open willow thicket northwest of Piney Ridge Lake; D047

**Vicia villosa* Roth; Hairy Vetch; rare, in open grassy edge by trail south of Big Sable River; D410

FAGACEAE (Beech Family)

Fagus grandifolia Ehrh.; American Beech; locally common in forested dunes; D186; ***C*** 6

Quercus alba L.; White Oak; rare, in mixed forest along east edge of park by Piney Ridge Road; D483; ***C*** 5

Quercus rubra L.; Red Oak; abundant in forested dunes; D277; ***C*** 5

Quercus velutina Lam.; Black Oak; common in jack pine barrens and ridgetops in forested dunes; D330, D444; ***C*** 6

GENTIANACEAE (Gentian Family)

**Centaurium erythacea* Rafn; Forking Centaury; occasional in wet meadows and margins of emergent wetlands; D119

GERANIACEAE (Geranium Family)

*†*Erodium cicutarium* (L.) L Hér.; Stork's-Bill; rare, in semi-open sandy/disturbed lawn near Hamlin Beach House; D318

Geranium robertianum L.; Herb-Robert; occasional in shaded forested dunes and disturbed sites; D200; ***C*** 3

GROSSULARIACEAE (Gooseberry Family)

Ribes cynosbati L.; Prickly Gooseberry; fairly rare, in shaded forested dunes; D364, D448; ***C*** 4

HALORAGACEAE (Water-Milfoil Family)

†Myriophyllum verticillatum L.; Whorl-leaf Water-Milfoil; occasional in aquatic bed wetlands bordering Hamlin Lake; D379; ***C*** 6

HAMAMELIDACEAE (Witch-Hazel Family)

Hamamelis virginiana L; Witch-Hazel; occasional along edges of forested dunes and shaded roadsides; D312; ***C*** 5

HYPERICACEAE (St. John's-Wort Family)

Hypericum kalmianum L; Kalm's St. John's-Wort; occasional, in wet meadow south of Big Sable River and in interdunal wetlands; D141; ***C*** 10

Hypericum majus (A. Gray) Britton; Larger Canada St. John's-Wort; abundant in wet meadow south of Big Sable River; D213; ***C*** 4

**Hypericum perforatum* L.; Common St. John's-Wort; fairly common in forest openings, along roadsides, meadows, and disturbed sites; D122

Triadenum fraseri (Spach) Gleason; Marsh St. John's-Wort; locally common in interdunal emergent wetlands; D419; ***C*** 6

LAMIACEAE (Mint Family)

Clinopodium vulgare L.; Wild Basil; rare, along shaded grassy roadsides; D436; ***C*** 3

*†*Glechoma hederacea* L.; Ground-Ivy; occasional along roadsides, in lawns, and disturbed riparian areas; D404

*†*Lamiastrum galeobdolon* (L.) Ehrend. & Polatschek; Yellow Archangel; rare, along edge of mixed forested dune bordering Piney Ridge Road; D368

*†*Leonurus cardiaca* L.; Motherwort; rare, along weedy/grassy trails bordering the Big Sable River; D126

Lycopus americanus Muhl.; Common Water Horehound; occasional, in wet meadow north of Big Sable River and along forested wetland edges elsewhere; D132; ***C*** 2

Lycopus uniflorus Michx.; Northern Bugle Weed; occasional, along edges of scrub-shrub and forested wetlands; D 219; ***C*** 2

Mentha canadensis L.; Wild Mint; occasional in emergent wetlands; D181; ***C*** 3

Monarda punctata L.; Dotted Mint; occasional in open dunes; D211; ***C*** 4

**Nepeta cataria* L.; Catnip; rare, in open mixed forest north of Big Sable River, west of dam; D130

Prunella vulgaris L.; Self-Heal; occasional along damp shorelines, roadsides, and trails; D169; ***C*** 0

†*Scutellaria galericulata* L.; Marsh Skullcap; occasional in emergent wetlands; D094; ***C*** 5

Scutellaria lateriflora L.; Mad-Dog Skullcap; occasional in emergent wetlands; D185; ***C*** 5

LAURACEAE (Laurel Family)

Sassafras albidum (Nutt.) Nees; Sassafras; occasional along forested edges and roadsides; D313; ***C*** 5

LENTIBULARIACEAE (Bladderwort Family)

Utricularia cornuta Michx.; Horned Bladderwort; locally common in interdunal emergent wetlands; D109; ***C*** 10

Utricularia intermedia Hayne; Flat-leaved Bladderwort; locally common in interdunal emergent wetlands; D216; ***C*** 10

Utricularia vulgaris L.; Common Bladderwort; rare, in interdunal pond within forested dunes; D073; ***C*** 6

LINACEAE (Flax Family)

Linum striatum Walter; Stiff Yellow Flax; rare, in wet meadow south of Big Sable River and sandbars bordering Hamlin Lake; D258, D417; ***C*** 10

LINNAEACEAE (Twinflower Family)

Linnaea borealis var. *longifolia* (Torr.) Hultén; Twinflower; locally common in jack pine barrens and open mixed forests; D054; ***C*** 6

LYTHRACEAE (Loosestrife Family)

*†*Lythrum salicaria* L.; Purple Loosestrife; rare along north edge of Piney Ridge Lake; D395

MALVACEAE (Mallow Family)

Tilia americana L.; Basswood; rare, edges of forested dunes; D050; ***C*** 5

MENYANTHACEAE (Buckbean Family)

†*Menyanthes trifoliata* L.; Buckbean; rare in emergent marshes; photo voucher only (Figure 20); ***C*** 8

MOLLUGINACEAE (Carpetweed Family)

**Mollugo verticillata* L.; Carpetweed; rare, sandy disturbed zone north of Hamlin Beach House parking lot; D350

MONTIACEAE (Blinks Family)

Claytonia virginica L.; Spring-Beauty; northern mesic forest; Herron 154 (2000); ***C*** 4

MYRICACEAE (Bayberry Family)

Myrica gale L.; Sweet Gale; occasional along edges of deepwater wetlands; D020; ***C*** 6

MYRSINACEAE (Myrsine Family)

Lysimachia terrestris (L.) Britton, Sterns & Poggenb.; Swamp-Candles; occasional in semi-shaded emergent wetlands; D380, D509; ***C*** 6

Lysimachia thyrsiflora L.; Tufted Loosestrife; rare in emergent wetlands/margins of lakes; D059; ***C*** 6

Trientalis borealis Raf.; Starflower; locally common in mixed forested dunes; D032; ***C*** 5

NYMPHAEACEAE (Water-Lily Family)

Nuphar variegata Durand; Yellow Pond-Lily; locally common in deepwater aquatic bed wetlands; D096; ***C*** 7

FIGURE 20. *Menyanthes trifoliata*. Leaves depicted. September 3, 2007. Photo by David C. Dister.

Nymphaea odorata Aiton; Sweet-Scented Water-Lily; locally common in deepwater aquatic bed wetlands; D098; ***C*** 6

OLEACEAE (Olive Family)

Fraxinus americana L.; White Ash; occasional, largely in upland forested dunes; D249; ***C*** 5

Fraxinus pennsylvanica Marshall; Green Ash; uncommon; largely in riparian and wetland habitats; D 397; ***C*** 2

ONAGRACEAE (Evening-primrose Family)

†*Epilobium coloratum* Biehler; Cinnamon Willow-Herb; occasional along margins of emergent wetlands; D262; ***C*** 3

*†*Epilobium hirsutum* L.; Great Hairy Willow-Herb; rare, along steep north bank of the Big Sable River; D353

†*Ludwigia palustris* (L.) Elliott; Water Purslane; rare, in backwater slough along south side of Big Sable River; D359; ***C*** 4

Oenothera oakesiana (A. Gray) S. Watson & J. M. Coult.; Oakes' Evening-Primrose; rare on open dunes; D155, D502; ***C*** 7

Oenothera perennis L.; Small Sundrops; rare, moist margins of interdunal emergent wetlands; D413; ***C*** 5

OROBANCHACEAE (Broom-Rape Family)

Agalinus purpurea (L.) Pennell; Purple False Foxglove; occasional in wet meadows and interdunal wetlands; D193; ***C*** 7

Conopholis americana (L.) Wallr.; Squaw-Root; occasional in forested dunes with American beech; D038; ***C*** 10

Epifagus virginiana (L.) Bart.; Beech-Drops; occasional in forested dunes with American beech; D238; ***C*** 10

Melampyrum lineare Desr.; Cow-Wheat; rare in jack pine barrens and forested dunes; D123; ***C*** 6

Orobanche fasciculata Nutt.; Clustered Broom Rape; rare in open dunes; McVaugh 11188 (1949); ***C*** 10

Pedicularis canadensis L.; Wood-Betony; rare in mixed forested dunes; D328; ***C*** 10

OXALIDACEAE (Wood-Sorrel Family)

Oxalis dillenii Jacq.; Common Yellow Wood-Sorrel; rare along roadsides and edges of parking lots; D255; ***C*** 0

PHRYMACEAE (Lopseed Family)

Mimulus ringens L.; Monkey-Flower; rare, shaded emergent marsh bordering forested dune; D175; ***C*** 5

PHYTOLACCACEAE (Pokeweed Family)

†*Phytolacca americana*, L.; Pokeweed; rare, shaded ravine in deciduous forested dune; D508; ***C*** 2

PLANTAGINACEAE (Plantain Family)

**Linaria vulgaris* Mill; Butter-and-Eggs; rare, grassy disturbed area within jack pine barrens; D224

**Plantago lanceolata* L.; Narrow-leaved Plantain; rare, along semi-shaded edge of marsh; D140

**Plantago major* L.; Common Plantain; rare, along shallow sandy/rocky edge of Big Sable River; D348

Plantago rugelii Decne.; Rugel's Plantain; rare, along west edge of Piney Ridge Road; D475; ***C*** 0

**Veronica arvensis* L.; Field Speedwell; rare, along trail through open mowed area; D018

*†*Veronica serpyllifolia* L.; Thyme-leaved Speedwell; rare, along trail in semi-shaded mixed forest; D087

POLYGALACEAE (Milkwort Family)

Polygala paucifolia Willd.; Fringed Polygala; occasional in mixed forested dunes; D037; ***C*** 7

POLYGONACEAE (Smartweed Family)

†*Fallopia cilinodis* (Michx.) Holub; Fringed False Buckwheat; rare, on open disturbed sandy hillside southeast of Piney Ridge Lake; D326; ***C*** 3

†*Fallopia scandens* (L.) Holub; False Buckwheat; rare, on open disturbed sandy hillside southeast of Piney Ridge Lake; D500; ***C*** 2

Persicaria amphibia (L.) Delabare; Water Smartweed; rare; in forested interdunal pond; D072; ***C*** 6

**Persicaria maculosa* Gray; Lady's-Thumb; rare, along shrubby south shoreline of Big Sable River; D358

Persicaria punctata (Elliott) Small; Dotted Smartweed; occasional in shaded emergent wetlands; D239; ***C*** 5

Polygonum articulatum L.; Jointweed; occasional in open dunes and openings in forested dunes; D267; ***C*** 8

**Rumex acetosella* L.; Sheep Sorrel; occasional in vegetated dunes and disturbed habitats, D013

**Rumex crispus* L.; Curly Dock; occasional along margins of emergent wetlands; D121

†*Rumex orbiculatus* A. Gray; Great Water Dock; occasional in shallow water wetlands; D243; ***C*** 9

RANUNCULACEAE (Buttercup Family)

Actaea pachypoda Elliott; White Baneberry; rare, in mixed forested dunes; D438; ***C*** 7

Aquilegia canadensis L.; Wild Columbine; rare, open hilltop meadow; D043; ***C*** 5

Coptis trifolia (L.) Salisb.; Goldthread; occasional, mossy margins of shaded wetlands; D268; ***C*** 5

Hepatica americana (DC.) Ker Gawl.; Round-lobed Hepatica; rare in sugar maple/hemlock forest on organic sandy soils; D008; ***C*** 6

†*Ranunculus pensylvanicus* L. f.; Bristly Crowfoot; rare, in semi-shaded emergent wetland; D339; ***C*** 6

†*Ranunculus sceleratus* L.; Cursed Crowfoot; rare, in semi-shaded edge of cattail marsh; D406; ***C*** 1

RHAMNACEAE (Buckthorn Family)

**Frangula alnus* Mill; Glossy Buckthorn; rare, along wetland edge of pond and along Piney Ridge Road; D465

ROSACEAE (Rose Family)

Amelanchier interior Nielsen; Inland Serviceberry; ND; Rogers 9277 (1953); ***C*** 4

Amelanchier laevis Weigand; Smooth Shadbush; occasional along margins of forested dunes and riparian banks; D019, D314; ***C*** 4

Aronia prunifolia (Marshall) Rehder; Chokeberry; rare, along margins of emergent and scrub-shrub wetlands; D055; ***C*** 5

Comarum palustre L.; Marsh Cinquefoil; rare, in semi-shaded backwater emergent wetlands; D097; ***C*** 7

Fragaria vesca L.; Woodland Strawberry; occasional in jack pine barrens; D319, D320; ***C*** 2

Fragaria virginiana Mill.; Wild Strawberry; fairly common along margins of open emergent wetlands and in meadows; D447; ***C*** 2

**Malus* x *purpurea* (Barbier & Cie) Rehder; Apple Hybrid; rare in grassy meadow; D316

Potentilla anserina L.; Silverweed; occasional, in wet meadows and banks along the Big Sable River; D024; ***C*** 5

Potentilla norvegica L.; Rough Cinquefoil; rare, on mossy log in emergent wetland; D179; ***C*** 0

Potentilla simplex Michx.; Common Cinquefoil; locally common in meadows, old fields, and forest openings; D402; ***C*** 2

Prunus pensylvanica L. f.; Fire Cherry; rare, in jack pine barrens; D412; ***C*** 3

Prunus pumila L.; Sand Cherry; common in open dunes; D152; ***C*** 8

Prunus serotina Ehrh.; Wild Black Cherry; occasional in forested dunes; D285; ***C*** 2

Prunus virginiana L.; Choke Cherry; occasional along margins of forested dunes and roadsides; D031; ***C*** 2

Rosa blanda Aiton; Wild Rose; rare, in jack pine/ground juniper barrens; D086; ***C*** 3

Rosa palustris Marshall; Swamp Rose; occasional, along margins of emergent wetlands; D164; ***C*** 5

Rubus hispidus L.; Swamp Dewberry; locally common along margins of emergent wetlands and in scrub-shrub wetland thickets; D459; ***C*** 4

Rubus strigosus Michx.; Wild Red Raspberry; occasional, in jack pine barrens, and edges/openings of forested dunes; D387; ***C*** 2

Spiraea alba Du Roi; Meadowsweet; rare, in interdunal wetlands within jack pine barrens; D329; ***C*** 4

RUBIACEAE (Madder Family)

Cephalanthus occidentalis L.; Buttonbush; rare, low moist area along west edge of Piney Ridge Road; D172; ***C*** 7

Galium aparine L.; Cleavers; rare, in openings in mixed forested dunes; D487; ***C*** 0

Gallium pilosum Aiton; Hairy Bedstraw; occasional, in jack pine barrens and dry meadows; D384; ***C*** 6

Galium tinctorium L.; Stiff Bedstraw; occasional, in semi-shaded backwater wetland sloughs; D170; ***C*** 5

Galium triflorum Michx.; Fragrant Bedstraw; occasional, in mixed forested dunes; D115; ***C*** 4

Mitchella repens L.; Partridge-Berry; occasional, in mixed forested dunes and margins of wetlands; D376; ***C*** 5

SALICACEAE (Willow Family)

Populus deltoides Marshall; Cottonwood; occasional, in open and semi-vegetated dunes, and along roadsides; D149; ***C*** 1

Populus grandidentata Michx.; Big-tooth Aspen; rare, in ridgetop openings of mixed forested dunes; D381; ***C*** 4

Populus tremuloides Michx.; Quaking Aspen; rare, in open deciduous forests along west side of Piney Ridge Road; D286; ***C*** 1

Salix cordata Michx.; Sand-Dune Willow; occasional, along open dunes bordering Lake Michigan; D147; ***C*** 10

Salix exigua Nutt.; Sandbar Willow; common along open dunes bordering Lake Michigan; D148; ***C*** 1

Salix myricoides Muhl.; Blueleaf Willow; occasional, along open dunes bordering Lake Michigan, and the margins of Piney Ridge Lake; D150, D401; ***C*** 9

†*Salix nigra* Marshall; Black Willow; rare; steep eastern edge of Piney Ridge Lake; D304; ***C*** 5

SANTALACEAE (Sandalwood Family)

Comandra umbellata (L.) Nutt.; Star-Toadflax; ND; Bartlett s.n. (1937); ***C*** 5

SAPINDACEAE (Soapberry Family)

Acer rubrum L.; Red Maple; common in mixed forested dunes; D301; ***C*** 1

Acer saccharum Marshall; Sugar Maple; locally common in deciduous and mixed forested dunes; D283; ***C*** 5

SAXIFRAGACEAE (Saxifrage Family)

†*Chrysosplenium americanum* Hook.; Golden Saxifrage; occasional, in mucky shaded forested wetlands; D450; ***C*** 6

SCROPHULARIACEAE (Figwort Family)

*†*Verbascum blattaria* L.; Moth Mullein; rare, along rocky south bank of Big Sable River; D127

**Verbascum thapsus* L.; Common Mullein; occasional, in meadows, trailsides, and forested dune openings; D117

SIMAROUBACEAE (Quassia Family)

*†*Ailanthus altissima* (Mill.) Swingle; Tree-of-Heaven; rare, along grassy west side of Piney Ridge Road; D171

SOLANACEAE (Nightshade Family)

**Solanum dulcamara* L.; Bittersweet Nightshade; occasional, along margins of wetlands and banks of the Big Sable River; D288

†*Solanum ptychanthum* Dunal; Black Nightshade; rare, in sandy disturbed interdunal opening; D264; ***C*** 1

URTICACEAE (Nettle Family)

Boehmeria cylindrica (L.) Sw.; False Nettle; occasional in emergent wetlands; D178; ***C*** 5

†*Parietaria pensylvanica* Willd.; Pellitory; rare, on disturbed sandy slope in sugar maple forest; D327; ***C*** 2

†*Pilea fontana* (Lunell) Rydb.; Bog Clearweed; occasional, along margins of emergent and scrub-shrub wetlands; D260; ***C*** 5

Urtica dioica L.; Stinging Nettle; rare, in moist riparian meadows and thickets; D202; ***C*** 1

VERBENACEAE (Vervain Family)

*†*Verbena bracteata* Lag. & Rodr.; Creeping Vervain; rare in weedy disturbed sandy ground; D696

Verbena hastata L.; Blue Vervain; rare, in wet meadow south of Big Sable River; D192; ***C*** 4

VIOLACEAE (Violet Family)

Viola labradorica Schrank; Dog Violet; ND; Rogers 9266 (1953); ***C*** 3

Viola lanceolata L.; Lance-leaved Violet; locally common in interdunal wetlands; D441; ***C*** 8

Viola macloskeyi F. E. Lloyd; Smooth White Violet; occasional, along shaded margins of emergent wetlands; D034; ***C*** 6

Viola pubescens Aiton; Yellow Violet; rare, in sugar maple/red oak forest south of Piney Ridge Lake; D449; ***C*** 4

Viola rostrata Pursh; Long-Spurred Violet; rare, in mixed forested dunes west of Piney Ridge Road; D012; ***C*** 6

VITACEAE (Grape Family)

†*Parthenocissus quinquefolia* (L.) Planch.; Virginia Creeper; occasional, on roadside trees near park entrance; D501; ***C*** 5

Vitis riparia Michx.; River-Bank Grape; occasional, in thickets and trees along roadsides; D248; ***C*** 3

BOOK REVIEW

Joe Johnson. 2016. *The Vascular Plants of the Bruce Peninsula, Ontario.* Privately published. 297 pages. Available from vascularplantsofthebrucepeninsula.wordpress.com or from the author at joejohnson.book@gmail.com. $28 CDN, plus postage (about $13-$14 for one book and about $1 for each additional book). Also available on Amazon at https://www.amazon.ca/gp/offer-listing/0995153507/ref=dp_olp_new_mbc?ie=UTF8&condition=new, but for $39 CDN + $6.49 CDN shipping.

The Bruce Peninsula, affectionately called "The Bruce," holds a special place in the hearts of botanists in the Great Lakes region. The limestone dominated habitats are scenic and rare in the region. The long peninsula protruding far into Lake Huron offers much shoreline plus unusual climatic settings. As a result, the flora is both rich and unusual, especially with species of great interest to botanists, amateur and professional—ferns and lycophytes (67 species), orchids (45 species), many disjuncts from the west and north, and even some unusual weeds! It is also a place special to the Michigan Botanical Club, the club having held two spring forays there. But for many years, the only sources of information about the plants were several bare-bones checklists and a flora dating from 1940.

Now we have a comprehensive flora, written by Joe Johnson, a legend in his own right having studied the plants of The Bruce for 40 years while living in Wiarton. Besides studying and documenting the flora, Joe has led innumerable field trips to sites on the Peninsula for many organizations, including the Michigan Botanical Club. It is immensely gratifying to see the product of Joe's life work in print.

This book is much more than an annotated flora. The introduction presents a great deal of information about botanical collecting and exploration on The Bruce, statistical summaries of the flora in great detail, a brief geological history of The Bruce, some settlement history, and brief notes on the climate and the biogeographical relationships of the flora, along with a discussion of the significance of flora from an Ontario and Canadian perspective. Habitats and plant communities, especially ones that are special on The Bruce, are also discussed, and striking species of the various habitats, especially the rarities and disjuncts, are listed at some length.

There is a detailed (and complicated!) section on the methodology and approach used in the work, including his approach to definitions of habitats, the basis of his phenology comments, his geographical subdivisions of the Peninsula, how abundance of the species is expressed, and the symbols and abbreviations used. Finally, there are maps of the Peninsula showing the subdivisions and the area covered.

The main body of the book comprises accounts, in substantial detail, of every species on The Bruce, totaling 1380. This includes scientific name, synonym(s),

common name(s), a letter-coded rendition of whether the plant is native to the Peninsula or not, whether it was listed in the old 1940 flora, the life form, its distribution on The Bruce by quadrants, and its national or provincial status—special concern, threatened, or endangered. This compresses a lot of information into a line. Beyond that, there is usually ample discussion about the rarity and distribution of the plant on The Bruce, a statement of when the species was first found, notes on its occurrence in surrounding areas, if relevant, and a great deal of detail on habitats. When available (as it is for most species), there is information on flowering dates, including averages and earliest and latest dates. Every species entry shows the personal touch of observations made over 40 years, often including comments on changing abundance. Some species even have comments on edibility (more discerning than in some edible wild plant books). This is not an identification guide, and there are no keys (Michigan Flora Online should work well!), but on the other hand, this is by no means just a standard, cut and dried, annotated list.

There is a great deal of information here about the occurrence and habitats of species on The Bruce. You can discover that the legendary American hart's-tongue fern (*Asplenium scolopendrium* var. *americanum*) is "Slightly uncommon overall, though it could be considered fairly common in Keppel Tp." *Calypso bulbosa* is now found only on "the Tobermory Islands and in the Tobermory (mainland) area, though it occurred from the 1960s (at least) to the early 1980s as far south as Sauble Beach" (where I saw it in 1985!) There are even hints of taxonomic work to be done—for example, under *Micranthes virginiensis*, we learn that "The Bruce Peninsula and Manitoulin populations (and presumably those of northern Michigan), seem different enough to the author from plants of southern Ontario to represent a separate taxon." And under *Oxalis stricta* you can read: "A rather delicious cold drink can be made by brewing plants of this species (minus the roots), as you would regular tea, and then cooling." Nearly 100 species are illustrated with color photos, and often more than one view is presented (e.g., flowers and fruits, overall views, close-ups of individual flowers).

Scientifically, the book can be viewed as a snapshot in time of the flora of The Bruce in 2014. The previous snapshot (by P.V. Krotkov) was taken in 1940. So the book is especially valuable and interesting, since occurrences of plants can traced through this time period with some accuracy. Joe collected a great deal on The Bruce to supplement the collections of other botanists, and almost every species listed is supported by collections examined; only sixteen species clearly noted as having "No collections" (e.g., *Pterospora andromedea*).

After the species accounts, there are valuable appendices noting rejected or excluded species, including a section on rejected reports of species that exist on The Bruce, but from areas outside their known occurrence, and even plants from the Grey County portion of The Bruce that occur nowhere else in Grey County. There is also a glossary, extensive references, and an index.

The book reflects Joe's highly focused attention to detail along with a deep concern for precision. Based on his personal observations, the book thoroughly reviews botanical information published by others about The Bruce, even his

own past work. All species previously reported for the Peninsula have been either accepted or rejected, and the reason for doing so is given in each case.

For those who know him, there is a lot of Joe's personality in the book. The carefully reasoned and intricately and complexly worded sections on methodology and on plant distributions and abundance, for example, need to be read with the same care and focus that Joe used in writing them! And many of the commentaries on abundance and rarity are highly qualified. *Picea mariana* is "Slightly uncommon overall." *Poa glauca* is "Uncommon (almost very uncommon)." *Piptatherum racemosum* is "Probably barely fairly common overall." Again, these need to be read in the spirit of precision with which they were written—although doing so is not obligatory; there is much here for the casual reader or for someone using the book merely as a quick reference.

We should be grateful for this wonderful new resource for Great Lakes region botanists and for anybody planning a botanical trip to "The Bruce."

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BOOK REVIEW

Claude A. Barr. 2015. *Jewels of the Plains*, Revised Edition, Edited by James H. Locklear. University of Minnesota Press, Minneapolis, London. xviii + 296 pp., hardcover. ISBN 978-0-8166-9801-1. $29.75.

Jewels of the Plains, which carries the subtitle "Wildflowers of the Great Plains, Grasslands and Hills," is one of those delightful one-of-a-kind books that defies classification. It is neither a flora, a wildflower guide, nor a checklist, though it partakes of elements of each. It is at once less and more than those categories. Less, because it does not treat all species known in the area covered, relatively few of the species that are covered are illustrated, and there is no formal means of identification. More, because the sections devoted to each species—or group of species—although including some descriptive elements, are more concerned with conveying a visual and emotional impression of the plant as one comes across it in its native habitat. Taking all these accounts in their totality, the book evokes the wonder and beauty of the plant life of the Great Plains, extending from southern Canada to northern Texas.

The first edition was published in 1983, shortly after the author's death in his 95th year. Claude Barr was born near Bentonville, Arkansas, in 1887. In the early years of the twentieth century, he settled in the southwestern corner of South Dakota, where he bought a homestead and eventually, in 1932, established a nursery that he operated for several decades. Over the years, he explored the plant life of the Great Plains and brought many Plains species into cultivation. He issued a regular catalogue to customers describing the ever-increasing number of species he offered through his nursery, and, along the way, published numerous articles in the horticultural literature. He had been planning *Jewels of the Plains* for many years, but work on it went slowly as a result of the burden of running the nursery and, at the same time, his active ranch. He realized by 1965 that if he continued in this fashion, the book would never be written. He had already sold his cattle and, at this time, he closed his nursery business, except for the sale of seeds, and devoted the rest of his years to finishing the book. The loss to his customers is well compensated by the gain to the rest of us, who now have the fruits of Mr. Barr's unique and devoted interpretation of the plant life of the Great Plains.

Perhaps the best way to convey the flavor of Mr. Barr's writing is to reproduce some snippets: Under "*Cirsium*. Thistle," he writes:

> Anyone who admires the wide, symmetrical, light rose-purple heads of thistles can well attempt to grow ***Cirsium undulatum***, which ranges over the length of the Plains. . . . [I]ts flower is one of the more beautiful wildflowers. . . . Foliage and stem are a harmonious gray green. Leaves have classic undulant margins, and all leaf extremities, stems, and involucres are well armed with stiff and sharp spines. . . . With its free but not troublesome stolonizing, new

rosettes appear here and there each year, though the original rosette dies after it has produced one to several fine flowers.

Delphinium geyeri is described as "arresting in the intensity and depth of its textured blueness." For the fetid marigold, the author writes "I hesitate to disclose the common name of . . . ***Dyssodia papposa*** because it denotes prejudice. . . . [It] is listed here to apprise . . . lovers of marigold fragrance that an inconspicuous . . . underfoot plant has provided a reminiscent whiff." *Viola adunca* is said to be a "quizzical little old man in deep blue" that "accepts the environment of Prairie Gem Ranch with charming grace." The blazing-star, *Liatris lancifolia* "dons its Tyrian raiment and commands attention in August." The bush morning-glory, *Ipomoea leptophylla*, "appears as a bold, loose mound of arching, tapering stems with lance-linear leaves," and, "[f]rom June to August come ample trumpets of subdued rose purple, . . . a welcome sight."

These gems go on for nearly 200 pages, treating the plants in alphabetical order by genus, including not only the descriptive language already sampled above, but also accounts of the garden value of each genus and species. Thus, this book is of value both to the botanical traveler through the Plains and to the native plant gardener.

The editor of the revised edition, James H. Locklear (who is the director of the Lauritzen Gardens in Omaha, a well-known horticulturist, and himself the author of an equally delightful book that is a comprehensive and authoritative survey of all 61 species of Phlox[1]) has very lightly edited Barr's original text, primarily limited to updating the nomenclature, helpfully indicating the changes in square brackets. In addition, he has provided an illuminating introduction, added a series of notes, and updated the already extensive bibliography, which includes, *inter alia*, all of Claude Barr's own publications. He has also replaced most of the color plates of the original with new ones (often of different species). Retained in the revised edition are the forward by H. Lincoln Foster, the author's extensive introduction, and a closing essay on the Great Plains plants in the wild and in the garden, a short essay by Ronald R. Weedon on the botanical contributions of the author, and a glossary and index (the latter updated by the editor).

This book is warmly recommended to all who rejoice in the plant life of the Great Plains or who appreciate fine writing that conveys personal observations of and experiences with those plants.

——Michael Huft

[1]Locklear, J. H. (2011). Phlox: A natural history and gardener's guide. Timber Press, Portland, Oregon.

ANNOUNCEMENT
MICHIGAN BOTANICAL FOUNDATION
CALL FOR GRANT APPLICATIONS

The purpose of the Michigan Botanical Foundation (MBF) is to provide support for Michigan botanical research, educational publications, and related activities that enhance the knowledge and preservation of Michigan's flora.

The MBF welcomes grant applications from anyone as long as such requests meet the Foundation's purpose and funding goals. MBF ordinarily makes grants in the range of USD $100–USD $1,500, although exceptions may be made. Geographic preference is the State of Michigan; however, funding for projects in the broader Great Lakes region may be considered. The MBF Board of Directors typically evaluates grants throughout the calendar year. All grant applications must be submitted electronically to the current MBF President, Judy Kelly, at hfcckelly@gmail.com.

To help achieve the mission of the Foundation, grants will be made to support endeavors, both research- and community-based, that are consistent with the mission of the Foundation. The Foundation is interested in funding the following types of projects:

1. Research projects that involve the study of Michigan plants, including, but not limited to: (a) state or federally listed (rare, threatened, or endangered) species; (b) competition between invasive and native species; or (c) floristic surveys;
2. Environmental projects that have one or more of the following features: (a) the project will raise public awareness of Michigan' s flora; (b) the project involves preservation, reclamation, or restoration of native habitat; (c) the proposed uses of the project site and access to it will result in public education;
3. Educational efforts such as workshops, institutes, conferences, and exhibits that hold the promise of increasing public awareness and knowledge of Michigan 's flora. Student scholarships to attend valuable botanical conferences and educational programs are also considered for funding.

These grants will be made on a case-by-case basis upon application to the Foundation when adequate funding exists. Applications for grants must be shown to have educational value with respect to Michigan's flora and may be funded in whole or in part.

Detailed guidelines for completing an application, a list of funding limitations, and expectations of grant recipients are available at http://michbotclub.org/mbf-grant-guidelines/. Further information about the Foundation is available at http://michbotclub.org/botanical-foundation/.

INSTRUCTIONS TO AUTHORS

Refer to http://quod.lib.umich.edu/m/mbot/submit for more detailed instructions, especially for formatting, style conventions, literature cited, and voucher specimen requirements. Please contact the editor with any questions.

1. Create text in 12-point Times New Roman font and double space paragraphs throughout. Research articles should be organized as follows: Title, Author(s) and address(es), Abstract with up to 5 keywords, Introduction, Materials and Methods, Results, Discussion, Acknowledgements, Literature Cited, Tables, Figure Legends, and Figures. Sections may be omitted if not relevant. All pages should be numbered.

2. For noteworthy collections, manuscripts should be formatted as follows. The title, "Noteworthy Collections," should begin each submitted manuscript, followed on the next line by the State or Province for the species reported. The next line should list the taxon of interest using the following format: Species Author(s) (Family). Common name. The rest of the manuscript should include the following named sections: (i) Significance of the Report, (ii) Previous Knowledge, (iii) Discussion, (iv) Diagnostic Characters (if desired), (v) Specimen Citations, (vi) Acknowledgements (if desired), and (vii) Literature Cited. Each of these sections is largely self-explanatory; however, the "Significance of the Report" section should be limited to a brief sentence or phrase indicating the significance of the collection(s), and this may be expanded upon in the "Discussion" section; the "Specimen Citations" section should include the relevant label data from the voucher specimen(s) including location data, collector(s), collection number, etc., as well as the Index Herbariorum acronym(s) of the herbarium or herbaria where the specimen(s) are deposited. The manuscript should end with the name and address of the author(s).

3. Non-research articles, such as book reviews, letters to the editor, notices, biographies and other general interest articles can be formatted as general text without the specific sections listed above. However, literature cited and any tables or figures should be formatted as described below.

4. Create tables either as an MS Word table or using a tab-delimited format. Each table is to be submitted as a separate file. Table captions should be placed at the top of the table. Any footnotes should appear at the bottom of the table. Please do not insert tables within the body of the text.

5. Send each figure as a separate file in a high-resolution format—eps, jpg, or tif. Figures like bar graphs that gain their meaning with color won't work—use coarse-grained cross-hatching, etc. Create figure legends as a separate text file, and the typesetter will insert them as appropriate. Please do not insert the figure in the body of the text file.

6. Citations: Please verify that all references cited in the text are present in the literature cited section and vice versa. Citations within the text should list the author's last name and publication year (e. g. Smith 1990). For works with more than 2 authors, use "et al.", and separate multiple citations with a semicolon.

7. Literature Cited: List citations alphabetically by author's last name. The first author's name is to be listed with surname first, followed by initials (e.g. Smith, E. B.), and subsequent authors are to be listed with initials first.Separate author's initials with a single space. The year of publication should appear in parentheses immediately before the title of the citation. The entire journal name or book title should be spelled out. Please put a space after the colon when citing volume number and page numbers.

8. Italicize all scientific names. Voucher specimens must be cited in floristic works and in any other study whose results depend on the identity of the plant(s). Papers citing plant records without documenting vouchers are generally not acceptable.

9. Manuscripts must be submitted electronically to the email address of the editor. All manuscripts will be reviewed by at least two referees.

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On the cover: *Brasenia schreberi.* Carolina Sandhills National Wildlife Refuge, April 30, 2017. Photo by Michael Huft.